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Glasgow Natural History Society

(formerly The Andersonian Naturalists of Glasgow)

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Front cover

Peter Macpherson checking a *Vicia orobus* (wood bitter-vetch) site on a rock face above the River Clyde east of Roberton.

Back Cover

Delegates attending *Darwin and Evolution Today* on 14 February 2009 at the Department of Adult and Continuing Education at the University of Glasgow to celebrate the bicentennial of Charles Darwin's birth. Dr Ruedi Nager is shown giving his talk on 'Darwin and the evolution of bargains'.

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EDITORIAL

How do we value Scotland's wildlife during an economic crisis?

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In the last two years we have seen the global economic crisis and recession come to dominate our lives. Savings at home, work and throughout society have forced us to consider what are essentials and what are luxuries. The economic downturn may change our relationship with the natural world and alter our attitudes to different species. For centuries Scotland's living resources have been economically important. Forests have been harvested for timber and our marine life has supported coastal communities. Large areas of land have been managed for field sports but more recently wildlife tourism is increasingly valued as a major source of income in rural areas. In 2010 it was estimated that the net economic impact of wildlife tourism in Scotland was £65 million and there were three thousand full-time-equivalent jobs associated with this industry (ICTHR, 2010). Conservation activities have been defended on the basis that they will make an important contribution to the economy. Here in the west of Scotland there has been considerable interest in the trial reintroduction of the Eurasian beaver (*Castor fiber*) in Knapdale, Argyll. The economic impact of reintroducing beavers is estimated to contribute over £2 million per year into the local economy through tourism and could be further enhanced by at least £1 million through focused eco-tourism operations (Campbell *et al.*, 2007).

Natural environments are increasingly being valued for their essential 'ecosystem services' that provide important functions for the benefit of humans (e.g. regulation of environmental gases, food production, recreation and health) and some of which may mitigate against the impact of climate change. Ecological economics is becoming an important discipline informing government policy. In Scotland, the services provided by our marine and terrestrial biomes have been assigned a monetary value of £17 billion each year (Williams *et al.*, 2003). To put this in context, it is equivalent to a quarter of Scotland's Gross Domestic Product (GDP), a little less than our total exports of manufactured goods and eight times more than our whisky exports.

Scotland's green spaces and natural habitats, particularly in urban environments are being recognised for improving the physical and mental health of individuals and communities (GreenLINK, 2010). As health is one of the greatest areas of public expenditure, there is growing realisation that the natural environment has an important economic value. For example, research suggests that if one in 100 inactive people took adequate exercise it could save the NHS in Scotland as much as £85 million per year (GreenLINK, 2010). The importance of Scotland's urban green spaces for local communities was widely discussed at our recent conference on *'Urban Biodiversity: Successes and Challenges'* from 30-31 October 2010 and the *Proceedings* will be subsequently published in this journal. Furthermore, we recognise the educational and entertainment value of wildlife in our parks, zoos, museums and increasingly on television and radio. These may seem costly on their own but by making a positive contribution to health and wellbeing it is money well spent.

With limited resources it is necessary for conservation bodies and government agencies in Scotland to calculate the economic cost of our ecosystems and wildlife. However, we should be cautious in making decisions based on "knowing the price of everything but the value of nothing". There is a danger we assign higher prices to charismatic species and lower prices to species we are prejudiced against. Although there is pressure to assign an economic value to the natural world, the 'currencies' we all use to value our environment are based on many different emotional and philosophical responses to wildlife (see examples in Allen & Ellis, 2010). It would be interesting to record the motivations of all our authors in this edition of *The Glasgow Naturalist* to study and write about such a fascinating range of species. However, it is clear from one naturalist at least, Peter Macpherson (front cover) that being a plant recorder for 30 years has nothing to do with money but everything to do with scientific curiosity and pleasure derived from being a botanist (see article Macpherson, this volume). Let us make sure that the *full value* of Scotland's wildlife and ecosystems, including their economic worth is appreciated despite the hard economic times we are faced with today.

ACKNOWLEDGEMENTS

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FULL PAPERS

Dune gentian - *Gentianella uliginosa* - a biodiversity action plan species - its taxonomic status and its relationship to conservation activity in the dune machair habitat

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ABSTRACT

The distribution, biology and habitat of dune gentian (*Gentianella uliginosa*) in Scotland, and also in England and Wales, are discussed; with special emphasis on life-span and the relationship with autumn gentian (*Gentianella amarella*), including the presence of intermediate forms. Current views on its taxonomic status of dune gentian are reviewed. Dune gentian is given species status in Stace (2010a) and varietal status in Sell & Murrell (2009). The provision of dedicated conservation management in Britain is being hampered by differing opinions on the taxonomic status of the plant. It is however advocated that appropriate management should be implemented, both for this distinctive form of gentian (whether or not a taxonomic consensus is reached) and for other plant and invertebrate species in coastal sand dunes and machair (dune machair system). Both habitats are the subject of Habitat Action Plans under the United Kingdom biodiversity programme. Success in the dune habitat of forms of low stature is not confined to dune gentian. The attributes of four dwarf plants, which occur partly or mainly in dunes, are described - early gentian, depauperate northern field gentian, Guernsey centaury and dwarf pansy. Three further dwarf forms, which once had species status, but are now amalgamated with other taxa, are also described, i.e. the dwarf forms of field gentian, seaside centaury and common centaury. Dwarf forms may have a potentially important role in assessing the nature and status of dune systems, especially in those cases where co-occurrences exist.

INTRODUCTION

In Scotland, dune gentian - *Gentianella uliginosa* - has been recorded from three sites, all on Colonsay (Rose, 1998). Prior to publication Dr Rose sent specimens for verification to Dr Pritchard, the co-author of the account of the genus in *Flora Europea* (Pritchard & Tutin, 1972), who was able to assess the material in both a European and British context. Dune gentian has been reported from five sites in Wales and one site in England (Holyoak, 1999; Jones, 1999; Preston *et al.*, 2002). There are also historic records from Derbyshire, England (Rich, 1996). It has not been reported from Ireland. The Colonsay populations are on sand which overlies rock at the edge of dune systems; or in dryish, vegetated hollows in dunes, which are not as deep or as clearly-defined as dune slacks. The location of the largest population is shown in Plate 1. In south Wales it characteristically occurs in dune slacks with creeping willow - *Salix repens*, though it can occur in other parts of dunes. The biology of the species in south Wales has been investigated, and existing information collated, by Kay & Johns (1995). Pollination ecology of the plant in Holland was studied by Petanidou *et al.* (1998). In this article 'populations' are collections of individuals with few or no plants in the intervening areas, usually occupying one habitat type. Hence one site may contain several more-or-less discrete populations.

Dune gentian is on Schedule 8 of the Wildlife and Countryside Act, and it is a United Kingdom Biodiversity Action Plan (UK BAP) species (Jones, 1999). The current and emerging threats to dune gentian indentified by both the 2005 and 2008 Biodiversity Action Reporting System (BARS) are available on the web (BARS, 2011). Dune gentian is on the Scottish Biodiversity List. It is an Argyll and Bute Local Biodiversity Action Plan Species (Anon. 2001). It is listed in The Argyll and Bute Local Biodiversity Action Plan 2010 - 2015 (Argyll and Bute, 2010). Its conservation status i.e. IUCN (International Union for Conservation of Nature) category is 'Vulnerable' in the latest Red Data List of British plants (Cheffings *et al.*, 2005). The species occurred in nine 10x10km squares (hectads) in Britain in the period 1987-1999 (Preston, *et al.* 2002). In this account rarity status follows Stace (2010a) not Rose (2006), see Appendix 1 for details, including the geographic scope of the status categories. Therefore the terms rare and scarce are used; not nationally rare and nationally scarce. (These terms are not capitalised in Rose (2006); or Stace (2010a) though they are in some accounts). Dune gentian is rare. This is the category for plants which occur in between one and fifteen 10x10km squares (hectads).

It was anticipated that this was one of the species that would benefit from the Coastal Heath prescription for species-rich areas under the five-year Scottish Rural Stewardship Scheme (Anon., 2004). An important element of the Scottish Rural Development Programme which started in 2008 is the conservation of species rich grasslands (Anon. 2011a). For species rich grasslands in Argyll, a regional priority (code ARG08) is supporting five significant habitats including sand dunes and machair; and/or nine species including dune gentian (Anon. 2011b). Colonsay has been allocated Important Plant Area (IPA) status by Plantlife International for the presence of slender naiad (*Najas flexilis*) (Plantlife, 2011). No other plant species are currently mentioned by name. In an earlier version of the web page other species cited to be of botanical significance were lesser water-plantain (*Baldellia ranunculoides)*, and the stoneworts *Nitella flexilis* and *Chara virgata*. Dune gentian was not mentioned in the earlier version of the web page. The criteria for IPA selection are given in Long (2009). Colonsay with its much smaller sister island of Oronsay has an area of 44 square km. Colonsay represents the most westerly location for the species in Europe.

The Scottish plants of dune gentian are small, typically between 10 and 50mm tall excluding corolla. This feature is linked in part to the dry, generally nutrient-poor nature of the sandy substrate. Furthermore the dunes are grazed by stock, usually cattle (*Bos taurus*) and sheep (*Ovis aries*); and also by rabbits (*Oryctolagus cuniculus*). The low plant stature reduces the possibility of total or even partial consumption. Plants emit an unpleasant odour, especially when handled; and are probably distasteful to rabbits and possibly to stock. Consumption by sheep and cattle is most likely to occur at high stocking levels when the plant is eaten together with the adjacent lower (usually) vegetation.

Plant height to base of corolla (i.e. to pedicel apex) is one of the component measurements used in an index to differentiate dune gentian from autumn gentian - *Gentianella amarella*. However the plant heights provided in published floras include the corolla. Autumn gentian occurs as two subspecies in Britian. The typical form, subspecies *amarella,* is present on Colonsay and as far north as Skye (Preston, *et al.* 2002). The northern form, subspecies *septentrionalis*, is only shown to occur in the Hebrides on Lewis in Preston, *et al.* (2002); but Farmer (not dated) reports it from Skye. Its conservation status, i.e. 'Red Data List' status, in Britain (see Appendix 1) is 'Near Threatened'. Its rarity status is scarce. This is the category for plants which occur in between sixteen and a hundred 10x10km squares (hectads). The Irish form, subspecies *hibernica*, is endemic to Ireland. Its rarity status is scarce. Autumn gentian is given as (annual or) biennial in Stace (2010a).

The south Wales plants of dune gentian are taller. Stace (2010a) gives the maximum overall height for British plants in general as 150mm (including corolla which he gives as 9-22mm long). When occurring in damp hollows, the twigs and branches of creeping willow will provide some protection from grazing.

Pritchard (1959) considered that the life span of dune gentian may sometimes be as short as 2-3 months. In August 1955 he observed plants at Oxwich on the Gower in south Wales that were "clearly biennial" in flower. In November they were dead, but their capsules still contained seed. If they germinated in October 1954 and died in October 1955 the life-span would be 12 months. If they germinated in August 1954 the life-span would be 14 months. Hence one cannot make the generalisation that dune gentian is a short lived form of autumn gentian. In overwintering plants of gentian species, a 'primary' basal rosette is initially present; this withers during the winter (Pritchard, 1959; Pritchard, 1972). A 'secondary' basal rosette, with different shaped leaves, is produced in the spring. For annual plants the rosette (when produced) is 'primary'. Autumn gentian in cultivation had 'primary' rosettes in June 1955 and 'secondary' rosettes in June 1956, Pritchard (1959). Hence rosette leaf shape separates annual and biennial plants (Pritchard, 1959; Pritchard, 1972). Dune gentian is given as annual or biennial in Stace (2010a).

Kay & John (1995) state that the seeds can germinate in the autumn or the spring; however they were unable to achieve germination in the laboratory. Dr Tim Rich (pers. comm.) germinated seed at Oxwich on the Gower in south Wales in 2003. Seeds were sown in autumn on site; they germinated in spring producing annual plants. A. Codling of Wolverhampton University (pers. comm.) has raised plants from seed from south Wales. They germinated in spring and flowered in July in the greenhouse. Pritchard (1959) did produce autumn gentian plants from seed, though he was unsuccessful with dune gentian.

Karlsson (1974) stated that "the Gentianaceae have an endotrophic mycorrhiza morphologically extremely reminiscent of the Orchidaceae". More recently it has been shown that some tropical, achlorophyllous members of the gentian family obtain organic carbon from other plants, through mycorrhizal fungi (Bidartondo *et al.,* 2002). It is conceivable that temperate, chlorophyll-bearing gentians may obtain resources via the same route.

The Habitat Action Plan for coastal sand dunes has a list of BAP priority species having significant populations on sand dunes. This list includes dune gentian (Anon., 1999a). Dune gentian is not included in the Habitat Action Plan for machair (Anon., 1999b) which covers the entire dune/machair system. In the National Vegetation Classification (Rodwell, 2000), dune gentian does not appear on any of the lists of species which are components of maritime communities, this is not unusual for rare species. Autumn gentian is listed as occurring in the following maritime communities; SD8 *Festuca rubra-Galium verum* fixed dune grassland, SD14 *Salix repens-*

Campylium stellatum dune-slack community, and SD16 *Salix repens-Holcus lanatus* dune-slack community. The plant associates of dune gentian on Colonsay are given in Rose (1998); and Gulliver (1997), who considered the grazed vegetation of two sample 2x2m quadrats to be nearest to the SD8e.

Plant names follow Stace (2010a).

RELATIONSHIP WITH AUTUMN GENTIAN

Pedicel characteristics

At every site in Britain where dune gentian occurs, autumn gentian is also present (Jones, 1999). Hybridisation between the two species has been reported (Holyoak, 1999; Jones, 1999; Pritchard, 1959; Pritchard, 1972, Rich and Jermy, 1998). A major distinguishing feature relates to the architecture of the plant. In dune gentian the terminal (i.e. uppermost) pedicel (flower stalk) occupies more than 50% of the total plant height to pedicel apex, i.e. excluding corolla (Stace, 2010a). In a heavily grazed environment, this is an advantage. It allows rapid upward growth, thereby reducing the time that the flower and capsule are at risk from being grazed. In damp dune slacks it may allow rapid growth to keep pace with the surrounding vegetation, with relatively low amounts of resources being used in the process.

Dr. Pritchard (pers. comm.) used the basal rosette (which lies on the soil surface) as the starting point for the measurements of plant height of three gentian species he described in Pritchard (1959); these form the basis of the descriptions in Stace (2010a). Applying a strictly theoretical approach the starting point should be at the cotyledons (usually-persistent in annual plants) or their scars, i.e. the point where the stem joins the root. This starting point was used by Gulliver (1999) for the following reasons. 1) On Colonsay the basal rosette is sometimes absent e.g. the leaves are more or less equally spaced along the stem. 2) For plants in turf or moss mats some of the internodes were below the upper surface of the mat. 3) As many plants had pairs of leaves which were closely-spaced (but not so close as to form a rosette) it was difficult to locate a starting point for measurements using leaf-pairs. 4) Use of the cotyledonary node allowed a large sample to be measured speedily and accurately. For some plants the height from ground level was also taken. In mid August 1998 the mean height of 174 plants, referable to dune gentian, was 25mm. At this time the upper capsule and pedicel was not infrequently brown and dead, while the lower leaves and stem were green. Internode counts from the cotyledonary node will include the nodes within the basal rosette for plants where the basal rosette is clearly defined. Should the total number of nodes be important taxonomically, the failure to count the nodes within the basal rosette may lead to a deficiency of critical information. Those nodes bearing rosette leaves could be recorded as such to aid comparison between studies. Plants without a primary basal rosette are likely to be annual.

The drawing of dune gentian in Stace (2010a), one of the drawings in Roles (1960), and two of the drawings in Rich & Jermy (1998) show plants with a pair of basal leaves but no rosette.

Number of internodes

Another difference is the number of internodes from the basal rosette upwards. This is 0-2(-3) for dune gentian; i.e. usually 0-2, can be as high as 3 (Stace, 2010a). For autumn gentian (both British subspecies and including the Irish subspecies) it is (2-(4-9)-11); i.e. usually 4-9, can be as low as 2 or as high as 11. For the typical subspecies it is 4-9(11). For the northern subspecies it is 2-7 (Stace, 2010a). The small size of plants on Colonsay has the consequence that 'terminal pedicel as a percentage of total plant height to pedicel apex' can be determined relatively quickly, compared with the number of internodes, as the nodes may be closely spaced. This is important as population sizes may be large. The plant in Plate 1, photographed on 14 June 1998, shows the ultimate extreme in dwarf-ness, with the pedicel arising from the basal pair of leaves. Commencing with the basal pair of leaves, this plant has an internode count of 0, and the pedicel length is 100% of the plant height to pedicel apex. There was no basal rosette. For this example the starting point for plant height is the basal pair of leaves: in dune gentian there may be a small space between the cotyledonary node and the basal pair of leaves. There is a tendency for a) internode number and b) terminal pedicel length as a percentage of the plant height to pedicel apex to be inversely related.

Some plants of dune gentian overwinter (Pritchard, 1959), as do typical plants of autumn gentian; and both often flower at the same time. Both species apparently frequently have a similar life-span. When comparing individuals from these two taxa, one cannot make the assumption that the low internode forms are shorter lived than the high internode forms. The fact that one species has a low internode number while other has a high one, suggests that there is considerable advantage to be gained from being dwarf.

Number of internodes in other* Gentianella *species

Zopfi (1991) found for field gentian (*Gentianella campestris*) the early flowering populations (n=5) all had *higher* mean internode numbers than the mid season flowering populations (n=3). For Chiltern gentian (*Gentianella germanica*) the early flowering populations (n=1) and all the mid season flowering populations (n=3) had *similar* mean internode numbers, but the values were higher for the late season flowering populations (n=2).

Zopfi (1991) concluded 'These [reported] results [on field gentian and Chiltern gentian] support the assumption that different flowering times have resulted from natural selection on the number of internodes'. However it is not a simple relationship, within one species populations with a smaller internode number do not necessarily flower earlier. No universal positive

correlation between internode number and lateness of flowering time was evident in his studies, similarly none exists for dune gentian and autumn gentian (when considered as a pooled entity) in Britian.

Lobes on the end of the calyx
A third difference is that in dune gentian the lobes (teeth) on the end of the calyx are uneven in size, and they are frequently turned back. In autumn gentian they are frequently equal in size and lie parallel to the corolla. Many of the dune gentians on Colonsay resemble autumn gentian in this feature, with even-sized lobes which slightly diverge from the corolla, or lie parallel to it. Some of the Colonsay plants have unequal lobes. One plant which was observed while in bud had one calyx with equal lobes, but the remaining two calyces had unequal lobes. This suggests that there is a strong environmental component to the expression of the character. The closely-related early gentian - *Gentianella anglica* - has somewhat unequal lobes, Rich *et al.* (1997). However these authors found that this character could not be used to reliably separate early gentian from autumn gentian, due to variation in this attribute in autumn gentian. Stace (2010a) gives calyx lobes more or less equal as a character for early gentian cf. some calyx lobes distinctly longer and wider than others for dune gentian.

Intermediate plants
In their survey of south Wales sites, Kay & John (1995) state that "intermediate plants, if any, are scarce and hard to find, and surviving populations of *G. uliginosa* [dune gentian] [are] predominately pure and uniform even when surrounded by or intermingled with *G. amarella* [autumn gentian]". These observations suggest that *during the study period* introgression presented no threat to the integrity of the populations of the two species in parts of south Wales. The flowering time for dune gentian is (July-) August-November; and for autumn gentian is (late July-) August-September (Pritchard, 1959). Using these flowering times, the lower-internode number taxon has members of the population flowering over the longer period. The time period for dune gentian refers to plants from south Wales. (On 14 June 1998 when dune gentian was in bloom at the largest dune gentian site on Colonsay - Plate 1 - autumn gentian was also in bloom).

By contrast, Pritchard (1959) found intermediate plants at two south Wales sites on the Gower, at Oxwich and Whiteford Burrows. He plotted the internode numbers (two populations pooled) alongside plots of dune gentian and autumn gentian. It is possible that some plants with an intermediate internode number may occur as a result of late germinating individuals of autumn gentian rather than being due to hybridisation.

Another viewpoint exists for intermediates between dune and autumn gentian and the parallel case of hybridisation between autumn gentian and early gentian reported by Rich *et al.* (1997). Greimler *et al.* (2004) interpret the intermediate forms as demonstrating ecotypic variation for one or both species, rather than hybridisation. The full text is presented in Appendix 1.

Several lines of evidence lead Petanidou *et al.* (1998) to conclude that dune gentian in Holland was a "predominant selfer". On the other hand Kay and John (1995) state that their "observations [of bumblebee movement] are, however mainly significant in that they show that pollen transfer between individuals and between the two species [dune and autumn gentian] probably occurs at quite significant levels."

Taxonomic views
Currently there is no unanimous consensus among botanists about the status of the dune gentian in Britain. This uncertainty appears to have hampered conservation activity, the thinking being that it is unwise to devote resources to a species whose validity may not be upheld. There are several different propositions. 1) Dune gentian will retain its identity as a full species, i.e. the status quo will prevail. 2) Dune gentian will become a variety or a subspecies of autumn gentian. 3) Dune gentian will be considered to be part of the range of variation occurring within autumn gentian. Dune gentian has species status in Stace (2010a) and varietal status in Sell & Murrell (2009).

Autumn gentian can be either biennial or annual (Stace, 2010a) as with dune gentian. It is possible that some of taxonomic uncertainty may be reduced by comparing taxa with similar life-spans, e.g. annual dune gentian with annual autumn gentian, biennial dune gentian with biennial autumn gentian.

FURTHER TAXONOMIC CONSIDERATIONS
The allocation of species status in the British flora, including that for difficult groups, is most frequently based on morphology (e.g. Rich & Jermy, 1998; Stace, 2010a); though relevant genetic information is used where available. Morphological features were used in the Europe-wide review of the entire genus by Pritchard & Tutin (1972) which is taken as a benchmark by many scientists. They were used by Rich *et al.* (1997) in their study of early gentian. They form the basis of the recent review of European members of *Gentianella* section *Gentianella* by Greimler *et al.* (2004). Both the genus *Gentianella* and the genus *Gentiana* are popularly known as 'gentians'.

Dr Tim Rich (pers. comm.) has undertaken a large analysis of the characteristics of dune gentian. The results of this unpublished study indicate that the plant material from Colonsay with dune gentian attributes is in fact autumn gentian.

New techniques in studying molecular genetics may shed light on plant groups where different interpretations of the morphological evidence are possible. One investigation already conducted, using techniques available in 1998 (Winfield pers. comm.), indicated that the Colonsay plants may, in fact, be part

of autumn gentian, i.e. proposition 3. See Appendix 1 for further details on the interpretation(s) and inferences of Dr Winfield's research.

Geographic scale may also be important. It is possible that some populations in Britain will be shown to be different from autumn gentian at the species level, while some are different at the subspecies or variety level, and yet others do not differ at all. Furthermore, considering the entire range throughout Europe, some populations of dune gentian may be as different from each other as they are from autumn gentian. Indeed it is quite likely that dune gentian has evolved separately at several different locations. Under this scenario the Colonsay plants may be at an early stage of this evolutionary process; and may provide an important example of speciation in action in response to a special set of habitat conditions. However it is possible that the plant has evolved on Colonsay from autumn gentian, but over a relatively long period of time in response to localised heavy grazing - see addendum. On the other hand, it is conceivable that the original form was a low internode taxon, and that autumn gentian has evolved from dune gentian and then expanded its range.

Taking the European view, the range of internode numbers, commencing with the basal rosette, given in *Flora Europea* for the two subspecies of autumn gentian pooled, that is, a) the typical autumn gentian (subspecies *amarella*), and b) the northern autumn gentian (subspecies *septentrionalis*: see later section) is (2-(4-9)-12); i.e. usually 4-9, can be as low as 2 or as high as 12 (Pritchard & Tutin, 1972), these are the same values as in Stace (2010a). Irish autumn gentian (subspecies *hibernica*) is not included in Pritchard & Tutin, (1972). The figure for typical autumn gentian (subspecies *amarella*) itself is 4-9(-11), i.e. lowest value is 4. Starting with the basal pair of leaves or basal rosette, plants of dune gentian on Colonsay (e.g. Plate 1) can have internode number = 0, as can plants from south Wales. This automatically means the terminal pedicel is 100% of plant height from basal pair of leaves to pedicel apex. If these two attributes become part of the range of autumn gentian, then the south Wales plants would be incorporated in autumn gentian as well as the Colonsay plants; unless new morphological characters were found to separate the south Wales plants from the Colonsay plants. Indeed it is likely that such a change of status would relate to dune gentian throughout its European range.

POSSIBLE TIME-RELATED CHANGES IN POPULATIONS

It is noteworthy that Dr Pritchard working on plant material from south Wales in the nineteen fifties considered that a) at Oxwich dune gentian could be either a biennial or an annual; and that b) at Oxwich and Whiteford Burows hybrids between dune gentian and autumn gentian were readily to be found (Pritchard, 1959). Indeed he considered hybridisation to be an important threat to the integrity of the species (Pritchard, 1959 p. 190; Pritchard, 1972 pp. 277-8). Kay and Johns (1995) detected little evidence of hybridisation between dune gentian and autumn gentian at the south Wales sites they investigated. Dr Rich (pers. comm.) found that at Oxwich those plants which germinated in spring 2004 from seed material sown in autumn 2003 were all annual plants, (seed banks are discussed subsequently). It is possible that the nature of individuals making up the populations of this short-lived taxon changes significantly over time.

THE *GENTIANELLA AMARELLA* (AUTUMN GENTIAN) GROUP AND IRISH AUTUMN GENTIAN

Dune gentian, early gentian and autumn gentian (typical, northern, and Irish subspecies) together make up the "*Gentianella amarella* group" (Pritchard & Tutin, 1972; Clapham *et al.* 1987). Irish autumn gentian is the only member of this set of taxa to occur in Ireland. Dune gentian and early gentian are absent from Ireland. Conceivably the founder population(s) in Ireland evolved into the Irish form, but no forms analogous to dune or early gentian developed. Irish autumn gentian is not included in Pritchard & Tutin (1972) or in Clapham *et al.* (1987).

FOUR OTHER DWARF, SHORT-LIVED PLANTS OCCURRING IN DUNES

General

Several dwarf, short-lived, spring or summer flowering plants occur in dunes, suggesting that the selection pressure producing such forms is widespread. Four examples whose range is entirely or partly in the west of Britain (including the Channel Isles), are briefly described. The two gentian species discussed occur in inland habitats in addition to dunes. The other two species occur only in coastal habitats. The first three are erect, the fourth erect to decumbent. The dwarf perennial, small adder's-tongue - *Ophioglossum azoricum* is discussed in the Conservation Management section.

Early gentian

Early gentian (*Gentianella anglica*) is a UK BAP species (Price 1999) which is a close relative of dune gentian; its height is up to 200mm, its life-span is (annual or) biennial (Stace, 2010a). It occurs at the same dune system as dune gentian at Braunton Burrows in north Devon. Both have internodes 0-3(4), starting from the basal rosette (Stace, 2010a: key couplet 3). Early gentian also occurs at coastal locations where dune gentian is absent, and in chalk and limestone grassland. Its rarity status is scarce. Cheffings & Farrell (2005) have recently reviewed the conservation status ('Red Data List' status) of all British plants. Early gentian has been placed on the 'Waiting List'. They based their assessment on Winfield *et al.* (2003) stating it to be "genetically very similar to *G. amarella* [autumn gentian], but flowers early and is morphologically distinct" - see Appendix 1. Until the situation is finally resolved, it no longer retains its former IUCN status which was 'Vulnerable'. (By convention IUCN categories e.g. Vulnerable, Waiting List are capitalised). It is noteworthy that in putting early gentian on the 'Waiting List', Cheffings

& Farrell (2005) appear to have placed greater weight on the reported genetical similarity with autumn gentian (involving laboratory procedures), than on the morphological distinctness, which can be determined in the field. The features of early, dune and autumn gentian (both typical subspecies and northern subspecies) can be readily compared using the accurate line drawings in Butcher (1961) and Stace (2010a); and the more schematic drawings of Roles (1960). Line drawings of dune gentian also occur in Rich and Jermy (1998). Early gentian has varietal status in Sell & Murrell (2009) and species status in Stace (2010a). Early gentian was amalgamated with dune gentian in the review of *Gentianella* section *Gentianella* carried out by Greimler *et al.* (2004), who emphasised the similarity of internode number between the two species of gentian. The aestival (June to early August) and autumnal (late August to November) flowering forms of many species of *Gentianella* known from the continent are discussed by Zopfi (1991), as well as forms which flower between these two periods. The widespread existence of early and late flowering forms of the same species in the genus probably explains the lack of significance attached to flowering date by Greimler *et al.* (2004). The extreme habitat specificity of dune gentian and early gentian (with co-existence at only one site in Britain, at Braunton Burrows) and differences in phenology (described subsequently) suggests that pending further work, the two taxa should be kept separate.

The flowering time for early gentian is (April-) May-June (-July) (Pritchard, 1959). Wettstein (1900), cited in Zopfi (1991), gives the flowering period for aestival races of several genera as June to early August and for autumnal races as late August to November. Hence if one applies the concept of aestival and autumnal forms to Britain for the pair of species, early gentian and dune gentian, e.g. at Braunton Burrows, the main period of flowering described by the terms needs to be earlier in the year by about one month compared with the continent.

The dwarf plant of dune gentian in Plate 1 was in bloom on 14 June 1998. This is within the flowering time of early gentian but outside the flowering time for dune gentian given by Pritchard (1959). Hybrids between early gentian and autumn gentian have been reported (Rich *et al.* 1997). There are no reports of hybrids between early gentian and dune gentian from Braunton Burrows, despite the fact that the flowering time of these two species, does partly overlap at this site (Holyoak, 1999). Holyoak (1999) does report hybrids between dune gentian and autumn gentian.

Depauperate forms of Northern autumn gentian
The northern autumn gentian is shown in Plate 1. It is illustrated with a basal rosette in Butcher (1961), where it is stated to be biennial. R. J. Pankhurst has described "depauperate" specimens from Berie sands in Uig on Lewis (Pankhurst & Mullin, 1991). Hence dwarf forms of northern autumn gentian can be present on dunes. "Depauperate" appears to have been used by Pankhurst & Mullin (1991) in the sense of very small plants, and not used in the sense of Kelly (1984) to indicate individuals with fewer seeds per fruit than large plants, a usage which involves considerable data collection.

Northern autumn gentian is described as being "probably endemic" (to Britain) in Stace (2010a), but is given as occurring in Iceland in Clapham *et al.* (1987). Farmer (not dated) states "Skye plants [of autumn gentian] probably belong to the distinctive northern subspecies *septentrionalis* which is endemic to the UK and almost confined to the far north of Scotland. The flowers are white, or faintly purple, on the inside, and reddish-purple on the outside". This is the colour combination shown in Plate 1. Pritchard (1960) made a detailed study of the taxon and considered it to be a separate species. It is shown or stated as occurring in five geographic areas, 1) Orkney and Shetland, 2) Lewis and the extreme north of mainland Scotland, 3) Grampians, 4) Cheviots, 5) mid west and north west Yorkshire, in Preston *et al.,* (2002) and in Stace (2010a). In some areas, e.g. 4 & 5, it may have evolved from local autumn gentian populations. The plant in Plate 1 was flowering on 18 August 1988. No flowering time for northern field gentian is given in Pritchard (1960), Stace (2010a), or Clapham *et al.* (1987). One inference is that the normal flowering time is the same for all three subspecies, i.e. typical, northern and Irish (subspecies *hibernica*). It is given as July to October for the aggregate species in Stace (2010a).

Guernsey centaury
Guernsey centaury, *Exaculum pusillum,* is an annual member of the gentian family occurring in dune slacks. It is dwarf, up to 40(100) mm tall (Stace, 2010a). The flowering time is July to September (Clapham *et al.*, 1987). (In this and subsequent cases where the flowering time is taken from Clapham *et al.*, 1987; it is not given in Stace, 2010a). Its rarity status is rare. The conservation and biodiversity categories used in relation to other species do not apply to the Channel Isles, see Appendix 1. Guernsey has an area of 63 square kilometres.

Dwarf pansy
Dwarf pansy, *Viola kitaibeliana*, (Violet family, Violaceae, not Gentianaceae) is a further example of a coastal, dwarf, annual plant up to 100 mm tall (Stace, 2010a). It occurs in dunes and short turf on sandy soil by the sea in the Isles of Scilly and the Channel Isles (Randall, 2004; Randall, 2005). The flowering time is April to May. It can flower as early as March and as late as July (Randall, 2004; Randall, 2005). Its conservation i.e. Red Data List status (for Britain i.e. Scillies not Channel Isles) is 'Near Threatened'. Its rarity status is rare.

Flowering times compared with dune gentian
The gentian and centaury species discussed have a flowering period around August except for early gentian which flowers around June. Dune gentian on Colonsay is unusual in that some (the minority) of the

individuals flower at the earlier time, and some at the later time. Dwarf pansy usually flowers April - March.

Occurrence in exposed locations

All four dwarf taxa occur, for part of their range, on islands or in west facing dune systems, i.e. locations where the degree of perturbation to the dune system during periods of high wind is likely to be greatest. The same applies to the dwarf form of field gentian, discussed in the next section and to the small adder's-tongue - *Ophioglossum azoricum* - discussed in Conservation Management section.

THE DWARF FORM OF FIELD GENTIAN

On Colonsay, field gentian - *Gentianella campestris* - frequently occurs on slightly more peaty substrates than dune gentian. A dwarf form, often with long pedicels, has been described as *Gentiana (Gentianella) baltica* or *Gentianella campestris* subspecies *baltica*. It is given annual in Butcher (1961), Pritchard (1972) and Pritchard & Tutin (1972). It is illustrated in Butcher (1961) with a basal rosette. The height, including corolla, of the drawn plant is 66mm. The height stated in the text is 50-100mm. In Europe it can be coastal or inland. Stace (2010a) does not recognise it as a separate entity at any taxonomic level. Plate 1 shows the dwarf form of field gentian from the largest dune gentian site on Colonsay. Normal-sized plants occur in the general vicinity though not always immediately adjacent.

There may be parallels between the occurrence of both dune gentian and early gentian at Braunton Burrows; and the occurrence of dune gentian and dwarf field gentian on Colonsay. The flowering time for field gentian is July to October (Clapham *et al.*, 1987). One of the distinguishing features of field gentian is the markedly unequal sepals. In describing dune gentian, Stace (2010a) states "There is some circumstantial evidence that this taxon is derived from *G. campestris* x *G. amarella"*. If, under this scenario, one original parent was *Gentianella baltica*, there would have been a genetic source of a) unequal sepals and b) long terminal pedicels in relation to total plant height. In Pembrokeshire field gentian occurs in the same 10x10km square (hectad) as dune gentian (Preston *et al.*, 2002). It does not currently share a hectad with the other Welsh or Devon sites for dune gentian. The co-occurrence in Pembrokeshire may be significant, given the general tendency for westerly winds in this region. It may possibly once have been more widespread in Wales, formerly occurring at sites at which it became extinct before botanical recording began. However a Principal Components Analysis of the AFLP [Amplified Fragment Length Polymorphism] data by Winfield *et al.* (2003) placed field gentian in a separate group from the pooled group of autumn, dune and early gentian.

Field gentian has declined greatly in Britain in Ireland (Cheffings *et al.*, 2005 page 3; Preston, *et al.* 2002). The total abolition of the taxon *Gentiana (Gentianella) baltica* is unfortunate. It would have been useful to know if the decline applied equally to annual and biennial forms.

DWARF FORMS OF CENTAURY, NO LONGER CONSIDERED TO BE DISTINCT SPECIES

Two dwarf forms of centaury (*Centaurium* species) are no longer considered to be distinct species. Nomenclature, flowering time, life span and plant height for these follows Butcher (1961) throughout, unless otherwise indicated. They provide two further examples of adaptation to exposed, coastal habitats.

Formerly known as sand-dune centaury (*Centaurium Turneri*), this dwarf, annual form, 30-100 mm, occurs in western and northern England. Butcher (1961) distinguished it from seaside centaury (*Centaurium littorale*), 30-250mm. Both plants flower from mid-July to early September. The two taxa are merged in Stace (2010a). Seaside centaury is stated to be annual in Butcher (1961); the composite taxon is given as biennial in Stace (2010a).

The dwarf form once known as capitate centaury (*Centaurium capitatum*), 50-100mm, occurs at Tenby and "on downs near the sea", Butcher (1961). It flowers mid-July to late August. Butcher (1961) distinguished it from common centaury (*Centaurium erythraea*); 100-380mm; which flowers mid-June to early October. Capitate centaury is given as annual in Druce (1926). Capitate centaury is stated to be perennial in Butcher (1961); and common centaury as annual. However the composite taxon is stated to be biennial (rarely annual) in Stace (2010a). Conceivably Butcher (1961) was in error in considering capitate centaury to be perennial. (One meaning of downs is dunes).

In each case the dwarf forms were distinguished by a flower or capsule character, as well as height and overall plant morphology.

CONSERVATION MANAGEMENT

The survival of what is still generally regarded as dune gentian relies on the presence of suitable habitat conditions. Provision of a grazing break for a) dune gentian alone or b) dune gentian and one or more other species of conservation interest would allow seed set (and in some cases spore production), and hence ensure the survival of healthy plant populations. Heavy grazing at other times of year will help to suppress more bulky, perennial plant species and to create some bare spaces in the sward.

Another species of conservation interest in dunes on Colonsay is the fern - small adder's-tongue, Plate 1. Its rarity status is scarce. It grows very close to some of the within-site populations of dune gentian in the large dune system which is the main dune gentian site on Colonsay, Plate 1. Small adder's-tongue is a dwarf fern with a larger congener, adder's-tongue - *Ophioglossum vulgatum*, with which it may be found growing, i.e. on Colonsay it shows parallels with dune gentian and autumn gentian. The 'season' for small adder's-tongue

in the Isles of Scilly is April-July; and for adder's-tongue is May-August (Parslow, 2006, Table 1). No dates are given for the species in (Clapham *et al.*, 1987). On Orkney and Shetland small adder's-tongue is fairly widely distributed, but adder's-tongue is absent, i.e. a local derivation of small adder's-tongue from adder's-tongue appears impossible, unless adder's-tongue was once present but has become extinct. This might have occurred if, once it had evolved locally, small adder's-tongue was more successful in the available habitats than adder's-tongue. Stace (2010a) states that small adder's-tongue is possibly derived from *Ophioglossum vulgatum* (adder's-tongue) x *Ophioglossum lusitanicum* (least adder's-tongue).

Conservation management which favours dune gentian could further promote flowering in other low growing dune plants, many of which provide pollen and/or nectar sources for invertebrates, e.g. wild thyme, *Thymus polytrichus*.

In order to conserve dune gentian, it would be possible to disfavour the taller autumn gentian to some degree by utilising a grazing break from mid July to mid September. This would to allow flower and seed production of dune gentian when the majority plants are in bloom. Heavy stock grazing prior to this, in June, and in early and mid July, would disfavour autumn gentian which at these times would be considerably taller than dune gentian. However this grazing would occur at a time when the early flowering individuals of dune gentian are in bloom. These are very much in the minority. The example in Plate 1 is very small.

It is important that the conservation management is dedicated to a particular species, to a group of species with similar requirements or to a locally defined objective; and is not simply a blanket prescription for a broadly defined habitat type.

The dune system eontaining one of the smaller populations of dune gentian on Colonsay in 1998 (Gulliver, 1999) also has the August flowering, UK BAP species, Irish Lady's-tresses orchid - *Spiranthes romanzoffiana* - present (Gulliver *et al.,* 2004). Two populations are currently exclosed against summer grazing, however neither exclosure contains dune gentian. The dune system has a record, from 1993, of the thyme broomrape - *Orobanche alba* - which is parasitic on wild thyme and whose rarity status is scarce. Thyme broomrape also grows on the heathery margin of the dune system. Thyme broomrape flowers from June to August (Clapham *et al.*, 1987).

All three sites of dune gentian on Colonsay are feeding areas for chough (*Pyrrhocorax pyrrhocorax*). Under management regimes involving periods of heavy grazing a short sward is generated, in which chough are able to successfully locate invertebrates in the upper layers of the sandy soil.

The UK BAP species fen orchid - *Liparis loeselii* - grows in the south Wales dunes (Southwood, *et al.*, 1999). It flowers in July (Clapham *et al.*, 1987). This species colonises new damp dune slacks (Harrap & Harrap, 2005; Southwood *et al.*, 1999). Grazing creates open areas in existing damp dune slacks; increases the number of bare spaces over entire dune systems, leading to the generation of new slacks in the less stable dunes; reduces the height of stands of creeping willow in slaeks (short term response); and tends to arrest the succession of the wet slacks to willow scrub areas (long term response). It is therefore a potentially powerful conservation management tool for the species. However it is essential to provide a grazing break to allow the target species to flower and set seed. Kay & John (1995) considered that management practices which kept dune slacks open and maintained a low vegetation height were likely to benefit both dune gentian and fen orchid. Fen orchid is capable of establishment over considerable distances. The plants at Braunton Burrows in Devon observed between 1966 and 1987 are believed to have originated from south Wales (Foley & Clarke, 2005). Four of the five sites for dune gentian in south Wales have records for fen orchid. Fen orchid was still present at two of these in 2000 (Harrap & Harrap, 2005); its rarity status is rare.

NUMBERS OF DUNE GENTIAN & INTERMEDIATE FORMS

General

This section makes the assumption that dune gentian continues to maintain its species identity and its various designations, both in Scotland and in Britain as whole.

Annual variation in numbers

The number of plants of dune gentian above ground varies from year to year. Petanidou *et al.* (1998) report large increases in population size following shrub clearance in Holland. This suggests the presence of a seedbank, though its size and stability or otherwise is not known with certainty. All plants examined on Colonsay contained seeds which appeared to mature rapidly and were quickly shed from the capsules. Surveys of the size of the dune gentian population need to be undertaken by competent botanists eapable of differentiating dune gentian from autumn gentian.

To determine the population size, which may run into many thousands, an adequate time allowance should be made. A sub-sampling technique may have to be employed. The figures from the largest site in units of 1,000 are c. 5,000 in August 1996 (Gulliver, 1998), c. 53,000 in August 1998 (Gulliver, 1999), <9,000 in August 2004 (Hawker & Hawker, 2004), e.15,000 in late July 2008 (Lavery, 2008). Accurate details of population trends are needed to gauge the success of conservation management.

Intermediate forms

On Colonsay, forms which are intermediate in morphology do occur in quantity and a protocol is required to reliably estimate the size of the dune

gentian populations. The intermediate forms may be somewhat disadvantaged compared with the parental types. Dwarf forms may mainly escape grazing and be less affected by wind scorch; taller forms (autumn gentian), if ungrazed and un-scorched, may produce very large numbers of seed; intermediate forms will have a lower seed output, but will still be susceptible to grazing. If crossing is taking place, then intermediates will be generated anew each year. Stems of autumn gentian, truncated by grazing, have been observed at the largest site for dune gentian. Grazed examples of dune gentian have been reported (Gulliver, 1999).

Studies on the relative fitness (in the genetic sense of the word) of the intermediate forms would make an important contribution to our understanding of the entire "*Gentianella amarella* group". As well as at locations where intermediates between dune gentian and autumn gentian occur, as on Colonsay; investigations should also be conducted at sites where intermediates between early gentian and autumn gentian are to be found.

CONCLUSION

There are four pressing needs in relation to dune gentian. Firstly, a comparison of the attributes of plants germinating in spring and in autumn in cultivation. Secondly summer survey work over at least two years to establish the size of the dune gentian populations on Colonsay at all three of the sites on the island, to gain an indication of year to year variation. Ideally parallel work should be undertaken at the English and Welsh sites. Thirdly, on Colonsay, information for June, July and August on the ratio of dune gentian plants in bloom to autumn gentian plants in bloom; (it is desirable that there should be a third category for plants with an intermediate internode number). The basal rosettes should be examined so that the balance of annual to biennial forms can be determined for dune gentian, for autumn gentian, and for intermediates. Fourthly, the implementation of dedicated conservation management, using the newly gathered information. Structured management of dunes, dedicated to a target suite of species with similar requirements, will bring wildlife benefits, even if the species status of dune gentian is not upheld in future decades.

The development of a consensus on the taxonomic status of the plant would be a further beneficial outcome. However as Stace (2010a) granted dune gentian species status and Sell & Murrell (2009) allocated it varietal status, development of a consensus does not appear imminent.

Furthermore there should be greater recognition of the importance of this UK BAP species as an element of the internationally important Scottish machair system (which includes dunes), Anon. (1999b).

In addition consideration should be given to the role of the dwarf forms of members of the Gentianaceae as indicators of the status of dune systems. It may well be that the presence of healthy populations of one or more dwarf forms indicates a dune system with a) a high level of grazing, sufficient to substantially control shrub and coarse grass development; and b) one where habitat variety is enhanced by the creation of bare areas, new dune slacks and new dunes during gales. Some of these dwarf forms no longer bear species status, but are still recognisable in the field for the purpose of site assessment. The depauperate form of northern autumn gentian should be included in the set.

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ADDENDUM: ON THE GRAZING OF THE DUNE MACHAIR SYSTEM ON COLONSAY, PAST AND PRESENT

Present day grazing of the dunes on Colonsay by stock and rabbits (*Oryctolagus cuniculus*), leads to consumption of seedlings of trees and shrubs, and an overall low sward height. Vegetation is further partly influenced by the recurrent presence of strong, salt-laden winds. Bare spaces may be created by sand deposition, by wind erosion of the sandy surface, by extremely heavy grazing by stock and rabbits, and by rabbit burrowing. Such bare areas maintain an open nature to the habitat which favours short-lived plants.

It is interesting to speculate on the nature of the dune and machair environment before the presence of sheep (*Ovis aries*), cattle (*Bos taurus*) and rabbits. The precise location of the dune system would change with changing sea levels. There is prehistoric evidence of red deer *Cervus elephas*) bones from middens on the sister island of Oronsay, (Grigson and Mellars, 1987; cited in Mithen and Finlayson, 1991). In their summary of the work, Mithen and Finlayson (1991) state "It appears that the Oronsay foragers had exploited two separate populations, one with average-sized animals for the early post glacial, and another with relatively small animals". Red deer would currently be able to cross from Oronsay to Colonsay at low tides. It is likely that it would always have been possible for deer to swim between the two islands. It may be that the bones relate to carcases brought to Oronsay for meat and/or as a source of bone and antler for tools. Pursuing the other possibility that live animals were present, they may have colonised spontaneously e.g. from Jura, or may have been brought by Mesolithic

man. It is therefore fascinating to consider the relationship of red deer numbers and habitat suitability for dune gentian at this period. The possibility of only a limited control of red deer populations by Mesolithic man, and conceivably consequent high grazing levels, cannot be entirely ruled out.

Berry (1979) describing the Outer Hebrides states "only two species (the Pygmy Shrew, *Sorex minutus*, and the Red Deer *Cervus elephas*), can be fairly definitely asserted to have arrived without the intervention of man". As the Inner Hebrides are less remote than the Outer Hebrides, it can be assumed that he held the same view for Colonsay and Oronsay. Describing the Inner Hebrides he states that fallow deer - *Dama dama* - and roe deer - *Capreolus capreolus* - have been deliberately introduced to the islands, (Berry, 1983); the absence of a mention of red deer further indicating that he considered them to be natural colonists. On the decline of red deer on Colonsay he states "Symington Grieve (cited by Ritchie, 1920) found a progressive reduction and final disappearance of red deer and wild boar [*Sus scrofa*] bones in caves on Oransay and Colonsay". More detailed information appears in Grieve (1923) who found "abundant evidence of the presence of the red deer (*Cervus elephas*) all through the deposits at Caisteal-nan-Gillean, Oronsay, and also in the lower strata of the Crystal Spring Cavern [Uamh Ùr; Kiloran Bay; Colonsay]. The evidence obtained by my excavations inclines me to the opinion that red deer were numerous upon these islands during the period of the occupation of Caisteal-nan-Gillean, but afterwards gradually decreased in numbers until they were probably exterminated about the eighth or ninth century." These findings indicate a well established population of red deer on Colonsay in the pre-historic and historic periods.

Grigson & Mellars (1987: cited in Serjeantson, 1990) believed that there was a real "possibility that red deer and conceivably other species could have been deliberately introduced into the outlying islands, such as Colonsay and Oronsay, by the Mesolithic communities themselves".

Mithen & Finlayson (1991) have reported that only nine microliths were found at a major Mesolithic site on Colonsay in a total of 1668 pieces of worked flint and 136 pieces of quartz, quartzite and chalcedony. One use of microliths was as tips and barbs for arrows. This finding is taken to indicate a very low deer population; or, possibly, a total absence of deer at that time on Colonsay, with other prey being the target for arrows containing microliths.

It would be desirable to have a more direct indication of red deer population size and distribution on Colonsay in the prehistoric and early historic periods.

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Appendix 1 Aspects of the paper by Winfield *et al.* (2003) on the "*Gentianella amarella* group"; times of flowering in *Gentianella* species; and the scope of the conservation, biodiversity and rarity status of vascular plants.

Plant material of autumn gentian and dune gentian from Colonsay was sent by the author direct to Dr Winfield in 1998. His early analyses suggested that the two were so similar that they should be treated together, as should the intermediate material which was also sent. Accordingly in Winfield *et al.* (2003), the

plots (and his Fig. 1) use one symbol for the south Wales plants of dune gentian; and one symbol for both a) Colonsay dune gentian and b) autumn gentian from all locations. A separate symbol is used for early gentian. Similarly in the tables, the entry 'Colonsay' refers to both dune and autumn gentian. Field gentian and Chiltern gentian - *Gentianella germanica* - were also studied, and were shown to be genetically distinct. "The other three species [south Wales dune gentian, early gentian, and 'autumn gentian'], however, were not clearly separable using either AFLPs [Amplified Fragment Length Polymorphisms] or cpSSRs [chloroplast Simple Sequence Repeats]", (Winfield *et al.*, 2003). (No dune gentian material from Devon was investigated). Commenting on Dr Winfield's research, Wendt (2004) disagreed with the above interpretation stating, "Clear phenotypical differences between the taxa [south Wales dune gentian, early gentian, and autumn gentian] are confirmed by allometric data presented in the poster [displayed at Royal Holloway University]. Moreover, phenological and morphological differences are persisting in common conditions in cultivation at Cambridge Botanic Gardens. This suggests that the original analysis, which examined non-coding portions of the genome, failed to detect small but significant genetic differences between the three taxa." More detailed analytical techniques, which might reveal differences between the three species, are now available, but they are extremely expensive to carry out, (Wendt, pers. comm.).

Winfield *et al.* (2003) is the journal account of the research first published as an English Nature Report 155, Winfield & Parker (2000). Commenting on Winfield & Parker (2000), (and also on Bateman & Sexton 2008); Stace (2010b) states 'for example apparently no DNA sequences have been detected between *Platanthera chlorantha* and *P. bifolia* (Bateman & Sexton 2008), or between *Gentianella amarella* and *G. anglica* Winfield & Parker (2000). Experienced taxonomists, especially field botanists, are well aware that in each of these two examples two separate taxa are involved, and therefore molecular differences must exist.' These remarks re-enforce those of Wendt (2004).

The situation in 2011 is that early gentian has been placed on the 'Waiting List' by Cheffings and Farrell (2005) but there is no change in the conservation status for dune gentian from Colonsay, south Wales or Devon. Despite the change in its conservation status, early gentian still retains its UK BAP status; its rarity status is scarce.

Early gentian is endemic to England and Wales. It therefore seems likely that it has evolved from autumn gentian since the last Ice Age and since Britain became an island, i.e. over an approximately 10,000 year period (Marren, 1999). Winfield *et al.* (2003) believe it evolved from autumn gentian due to heavy grazing or to haymaking in July creating two flowering niches, pre July (continental aestival with an adjustment for Britain) and post July (continental autumnal with an adjustment for Britain). Zopfi (1991) has pointed out that for *Gentianella* species many populations occur at sites which are not managed by man and never have been, and yet contain aestival, or autumnal or monomorph (intermediate) flowering forms; as well as forms flowering at times between these three categories, e.g. see Table 4, page 147. Rich *et al.* (1997) report early gentian in Cornwall growing on cliffs; for example see sample 14. (Zopfi, 1991, further believes that the basic, highly varied pattern of flowering time has been simplified in agricultural habitats into two forms aestival, or autumnal).

Greimler *et al.* (2004) recognise early gentian, though they amalgamate it with dune gentian. They also believe that species boundaries are affected by ecotypic variation. The full text of the relevant sentence is presented, to aid an understanding of their viewpoint. "Considering the poor genetic differentiation within the *G. amarella* group (data in Winfield *et al.* 2003) this rather reflects ecotypic variation of one species occurring with various fully compatible variants in various habitats than differentiation on the species level (with subsequent hybridisations) as suggested by Rich *et al.* (1997) and Holyoak (1999)."

Gulliver (1988) described a single peak of species in bloom around early July in a range of non-mown grassland communities and Gulliver (unpublished) has found a single peak in a variety of non-woodland plant communities, often in July. The evolution of June flowering forms of *Gentianella* in unmanaged areas in Britain may be related to several co-acting evolutionary forces, including the presence of this peak of plants in bloom, and an associated competition for pollinators. In Britain it is possible that the same may apply to August flowering forms.

The geographic scope of the three designations (conservation, biodiversity and rarity status) varies, e.g. see Rose (2006); Gulliver, *et al.* (2008). Furthermore the scope for rarity in Stace (2010a) is different from previous authors. Red Data Book (conservation) status applies to Britain, but not the Isle of Man. UK BAP status relates to Britain, Northern Ireland and the Isle of Man. The Channel Isles are excluded in these two cases. Rarity status in some published sources, e.g. in Rose (2006) i.e. nationally rare or nationally scarce relates to Britain, and the Isle of Man. It excludes the Channel Isles. Stace (2010a) uses the term uncommon (occurring in 101-250 10x10km squares), as well as rare (occurring in 1-15 10x10km squares), and scarce (occurring in 16-100 10x10km squares). He includes the Channel Isles and all Ireland in the version of rarity status that he uses; and his designations are utilised in this account. From a biological point of view these political divisions are unfortunate. In Ireland there can be an overlap of designations for biodiversity. Hence Irish Lady's-tresses has UK BAP status as it grows in Northern Ireland, and it has an all-Ireland [biodiversity] Species Action Plan (SAP) status as it grows both in the Republic of Ireland and in Northern Ireland.

Plate 1

a. The largest site for dune gentian on Colonsay in April 2010. The plant grows in dry zones with varying degrees of open-ness to the sward; and in damp, very-shallow hollows. Performance of dune gentian in sandy soils with different quantities of humus may vary with summer wetness/dryness. The proximity of the different micro-habitat types eould well be an important feature of the dune system which assists the long term survival of the species. A low stand of burnet rose - *Rosa pimpinellifolia* - occurs on one part of the site, no other woody plants are present.

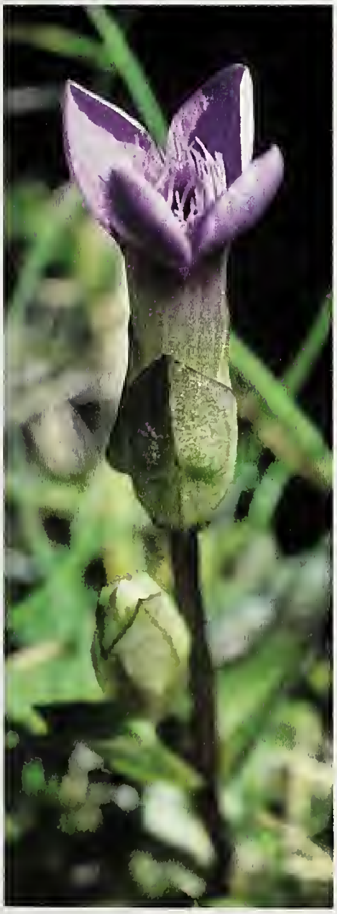
a. Inset. An extremely small plant of dune gentian on Colonsay on 14 June 1998, in bloom in advance of the main flowering time for dune and autumn gentian. The pedicel (flower stalk) arises directly from the pair of basal leaves. Above the basal pair of leaves there are no internodes, i.e. no sections of stem between pairs of leaves. Such very small plants of dune gentian almost certainly have a short life span and hence less chance of being grazed. In this one-flowered plant, the terminal pedicel is the only one present. Autumn gentian was also in bloom on this date.

b. The northern autumn gentian flowering on 18 August 1988 in sloping machair behind dunes at Traigh Mhor, New Tolsta, Isle of Lewis, showing the characteristic flower colour for this subspecies. The plant architecture, with the terminal pedicel representing much less than half of plant height to pedicel apex, is an important feature of all three subspecies of autumn gentian, i.e. the typical subspecies, the northern subspecies and the Irish subspecies.

c. A dwarf form of field gentian on Colonsay on 23 August 1996. The open flower surmounts the long terminal pedicel. Arising from the axil of the uppermost pair of leaves is i) to the left, a fairly-long, second pedicel with an unopened flower; and ii) to the right, a calyx enclosing 90% of a young flower. Below these in the centre is a further unopened flower on the same plant. There is a part-opened flower on an adjacent plant. Such dwarf forms were previously known as *Gentianella baltica*. In this taxon the pedicels represent a greater percentage of plant height to pedicel apex than for the normal forms of the field gentian.

d. Small adder's-tongue fern growing on part of the largest dune gentian site on Colonsay, on 14 June 1998. The close relative - adder's-tongue fern - was growing nearby. The fertile blade is on the inside of the sterile blade, both structures being paired. In adder's-tongue fern these organs are very rarely paired and are considerably larger. On Colonsay both species grow together quite often. On Orkney and Shetland small adder's-tongue is fairly widely distributed, but adder's-tongue is absent. (The allocation of names to the parts of ferns varies considerably from one text to another).

Plate 1



b

c

d

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Patterns of flowering on continuously-grazed dune and machair on Colonsay

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ABSTRACT

The pattern of flowering was investigated in 5x5m *plots* on dune and adjacent machair, both continuously grazed, on the Isle of Colonsay. During the study period twenty six species were in bloom in the machair plots (pooled) and twenty one in the dune plots. Approximately half the total number of species in bloom (thirty two) occurred in both the dune and the machair plots. A greater proportion of flowering records were from insect pollinated species (cf. wind pollinated) on the machair compared with the dunes. Sward composition was studied using 1x1m and 2x2m *quadrats*. Machair quadrats showed greater species richness; there was no overlap with dune quadrat values. For the species flowering in both stand types, the average value of the parameter 'plots-per-species' (treating each species as equivalent to every other; see Tables 3 & 4 for details) was always greater for machair than dune, though the differences were not large. However for these species which flowered on both dune and machair, the total number of species in bloom, pooled over all plots, was greater on the dunes on three dates (Table 4). In addition, considering all species, the average number of species in bloom per plot was greater on the dunes on two dates (Table 3). Several species had a relatively long flowering period; some were in bloom throughout the full 3.5 months of the study period. A greater proportion of the total set of records (n=635) was due to species which flowered throughout the study period on the machair compared with the dunes. This feature is important for nectar and pollen feeding insects and for human visitors to the dune and machair. Continuous, heavy grazing has prevented the upward growth of flowering stems. There was a repeated production of flowers low to the ground in some species which appears to have extended the flowering season. Throughout the study period the vegetation height in the machair plots was 1cm. This low uniform sward, with an absence of less-palatable taller plants e.g. meadow buttercup, and in which the grassland 'weed' ragwort is extremely rare, is one of the many forms that the machair can take. In the dune plots the vegetation was made up of three layers, the upper layer being marram plants. Despite the many differences between the two stand types, both belonged to the same National Vegetation Classification plant community.

INTRODUCTION

The variation in climatic regime, soil type, management systems and biotic interactions provide, on one hand, much of the fascination of ecology and biogeography; but on the other hand produce difficult subjects for study, as it is rarely possible to investigate one factor, condition or interaction without other parameters being present. This inherent variation is often reduced in the dune machair system where there is one substrate - wind blown sand containing shell fragments. However it will frequently be subject to variations in depth, in hydrology, in humus content and in calcium carbonate content. Ritchie (1967) stated "The calcareous proportion appears to decrease with age, distance from the sea and amount of water saturation". The broad climatic regime will be constant, with microclimatic differences, especially at dune crests and in dune slacks. In some cases, e.g. as in the studies on Tiree made by Vose, Powell and Spence (1957), and on many of the dune machair systems on the Islands of Colonsay and Oronsay, the same stock will graze the whole system.

Reviews of the ecology, management and importance of the machair are provided by Angus (2001), Angus (2006), Angus and Dargie (2002), Anon. (1999a), Dickinson & Randall (1979), Kent *et al.* (2003), Love (2003), Love (2009) and Rodwell (2000). The landscape, botanical and avifaunal interest of the dune machair system is important in attracting visitors and naturalists to the west of Scotland (Kent *et al.*, 2003). Both dunes and machair come under the umbrella machair category in the UK machair Habitat Action Plan (HAP), (Anon., 1999a). The National Vegetation Classification (NVC) provides a system for classifying plant communities in Britain. Coastal, i.e. 'Sand Dune' - SD - communities are described in Rodwell (2000). Angus (2006) lists the grassland communities of the dune machair system. On the list the SD8 i.e. the '*Festuca rubra-Galium verum* fixed dune grassland' is made up of five sub-communities 8a, 8c, 8d, 8e and 8x. The SD8b does not occur in machair. The SD8x is a machair grassland type recognised by Dr T. Dargie (Angus, 2001; Angus, 2006). It does not appear in the published NVC, i.e. Rodwell (2000). Marram grass (*Ammophila arenaria*) can be a major or a minor component of machair grassland. It has tough leaves and stems and is normally avoided by stock. The dune machair system includes two further grassland communities (Angus, 2006); the SD17 dune slack

community and the MG11 inundation grassland (Rodwell, 1992). In addition the landward fringe of the machair may be occupied by the 'climbing dune' sub-community - SD8z (Angus, 2001; Angus, 2006). Other components of the entire dune machair system e.g. semi-fixed dunes, machair lochs and their margins, and the often-seasonal machair burns, support other plant communities. Plant communities are often used as a framework in ecological studies. The size and mobility of animal species will determine to what extent the animal community is related to plant community structure. Plant names follow Stace (2010).

The main aim of the study was to investigate differences between dune and machair in the pattern of flowering over the season. All species in bloom were recorded and plant names follow Stace (2010). Insect pollinated species will influence other organisms in the relevant community and are considered as a discrete group. A secondary aim was to record the nature of vegetation in order to demonstrate the influence of the continuous grazing regime. Many studies of dune and machair vegetation are based on a single site visit, e.g. the dune and machair survey of Scotland by Dr T. Dargie and co-workers (Dargie 1993). Some of the biological aspects of this survey are discussed in Kent *et al.* (2003). Relatively few published studies involve a sequential set of visits which was the core feature of this investigation. Several detailed aspects of the flowering characteristics in dune and machair were investigated. Firstly, the overall number of plant species in bloom. Secondly, the number of plots holding plants in bloom for each species. Thirdly, the seasonal pattern of flowering. These features are of relevance to nectar and pollen feeding insects, and indicate the natural history interest to human visitors. Seed production was not investigated. However the dunes may represent an important seed source, with only low quantities of seed being produced in the machair. Movement of seed could be by wind or animal agency. Openings for seedling establishment may be created by rabbit activity on dunes and machair; by localised over-grazing on the machair; and by severe winds, particularly on the dunes. No damage by erosion associated with humans was obvious.

METHODS

Study site

The study site was a flat stretch of machair adjacent to well developed dunes at Ardskenish on Colonsay in 1x1km squares (monads) NR3591 & NR3592. The whole area was continuously grazed by sheep with some cattle present. The fine turf of the machair provided good grazing, the sward typically being 1cm high. Marram grass (*Ammophila arenaria*) was not detected, probably being unable to survive under such intense grazing conditions. By contrast the dunes contained much tall marram grass. On the dunes the sward between the marram tussocks was less heavily grazed than the general sward on the machair. Thus the two stand types varied greatly in physical structure while belonging to the same plant community (see Discussion); and with similar substrate and climate. Invertebrates were exposed to direct consumption and to trampling on the machair, whilst having niches e.g. at the base of marram clumps in the dunes. Nests were exposed to trampling and predation on the machair, but are less visible and less at risk from trampling in the dunes. The taller height of all plants in dunes had the consequence that a full range of plant parts, stems, side branches, young and old leaves, vegetative and flower buds, flowers and seed were available to invertebrates as a food source. Plants on the machair exhibited a smaller range of plant parts. Other dune and machair sites on Colonsay and Oronsay have been studied, though less intensively.

Sward characterisation using quadrats

Plant presence/absence in six 2x2m quadrats and one 1x1m quadrat in dune and machair was recorded on 24 June 1992 (five quadrats, all 2x2m), 5 July (five quadrats, all 2x2m) and 17 July (four quadrats).

Phenological studies using plots

Five 5x5m plots were established in a 25x25m large plot (reference area) in dune and in machair and visited on seven occasions from 4 June (day 156) to 19 September 1992 (day 263). The large plots were separated by 500m. The species in bloom on each plot were recorded on each visit. Preliminary visits were made to these plots before 4 June. These initial observations indicated the number of plant species in bloom to be low and hence recording started on 4 June. A minimum of one individual plant in bloom was used to generate a record for each species. Three 5x5m plots contained one 2x2m quadrat which was used for sward characterisation, one 5x5m plot contained two 2x2m quadrats and one 5x5m plot contained one 2x2m quadrat and one 1x1m quadrat. The number of species in bloom in the 1x1m quadrat, and in a single 2x2m quadrat was recorded on one date: 17 July. The dune plots ran seawards from the highest dune in the area. 1992 was a leap year. Hence the conversion from date to day number is different by one day from dates in a non-leap year.

Vegetation height

In this study vegetation height was defined as the distance from ground level to the point where the bulk of the stems and leaves thinned out markedly. There is a degree of subjectivity in determining this point, which is refined with practice, frequently it is circa 66% of the height of the tallest leaves (or stems where present); the late D.A. Wells (*pers. comm.*). The parameter is widely used in vegetation studies. It was measured on five visits to the plots and at the quadrats. Height was recorded at 1.0 1.5 or 2.0cm, then at 1cm intervals to 20cm, then at 5cm intervals to 70cm. On the dunes, three layers were recognised, a Lower Layer (LL), a Middle Layer (ML), both without marram; and an Upper Layer (UL) consisting of marram grass, for further details see Results section.

Statistical note

Parametric statistical tests are applied to data which are normally distributed. These involve determining the

probability of two or more samples belonging to the same population. Where there is no overlap in sample values, the two samples can be stated to be different, i.e. the Null Hypothesis is rejected. It is unnecessary to undertake a statistical test based on probability under these circumstances; indeed it is technically invalid so to do. Non-parametric tests are applied to data which cannot be assumed to be normally distributed. One form of non-parametric test is the Wilcoxon test for paired values. Where every pair has a change in values in the same direction i.e. all positive or all negative, the two samples can be stated to be different. In this situation is unnecessary to undertake a statistical test based on probability; indeed it is technically invalid so to do. However if all the pairs change in value in the same direction except one, for which there is no difference in value between the members of the pair, a test should be undertaken. The same notes apply to untransformed and transformed normally-distributed paired data. Where 25 or more replicates are used, the z test (designed for normally distributed data) can be applied to non-parametric data; the influence of the non-normal nature of the data is minimal under these circumstances.

The standard statistical convention for probability (P) levels, e.g. see Heath (1995), has been utilised; i.e. 'significant' for a probability of between 5% and 1%, 'highly significant' for a probability of between 1% and 0.1% and 'very highly significant' for a probability below 0.1%. In this account each species at any one date can have one of five values (or zero if not in bloom) i.e. present on one, two, three, four or five plots. The limited range of categories restricts the shape of any frequency distribution. The only safe course of action is to treat the data as non-parametric.

RESULTS

Effects of scale on number of plants in bloom in plots and on species presences in quadrats

The effects of scale on number of plants in bloom *in plots* are shown for a sample date - 17 July, (Table 1). Recording flowering at the $25m^2$ level has provided a balance point between a small sized sample unit containing few values which may be unrepresentative; and a large sized sample unit which is time consuming to survey in relation to the extra information obtained.

At this site, about one third of the species flowering in the $125m^2$ area were in bloom at the $1m^2$ and $4m^2$ level for dune and machair (Table 1) on this date.

Presence/absence in *quadrats* was recorded for part of the total set of values at three different dates, see Methods section, after the number of plants in bloom had been recorded. Hence the creation of composite values over two dates has been undertaken to provide the $25m^2$ value which is made up of $6x4m^2$ quadrats+$1x1m^2$ quadrat. The $125m^2$ value consists of the $25m^2$ value plus plants recorded in bloom in one or more $25m^2$ plot (n=5) over the date range given in Table 1. There was no overlap between the number of species present in the $4m^2$ dune quadrats (12-17; median 15) and the number of species in the $4m^2$ machair quadrats (22-25; median 23). The two stand types can be stated to be different in this regard: see 'Statistical note' in Methods section.

Vegetation height

The vegetation height on the machair was low and uniform, 1cm throughout; the vegetation height in the dunes was taller (Table 2). On 17 July, when flowering was recorded in sample quadrats as well as plots; the height of the Lower Layer on the dunes was 5cm, the Middle Layer 14cm and the Upper Layer 50cm, though the tallest leaves of marram will be much longer than this. On the first visit only one non-marram layer was evident, full differentiation in structure occurred by the second visit (note a, Table 2). No marram plants were detected in the 2x2m quadrats on the machair, and there were no records of flowering in the 5x5m plots, it may therefore be presumed to be absent.

General pattern of flowering

Of the 32 species which flowered, 19 were insect pollinated and therefore had a more direct influence on the invertebrate populations, and would be more apparent to human visitors (Table 3). Thirteen were wind pollinated with greenish or brownish flowers. With the exception of ribwort plantain (*Plantago lanceolata)*, which exhibited a second flowering on the machair, no other wind pollinated species was in bloom in the last three recording periods on the machair. The values in Table 3 are the number of plots in which each species was recorded in bloom on each visit. Two hundred and ninety one of the 345 records on the machair (84%) were insect pollinated flowers; 192 of the 290 records (66%) on the dunes were insect pollinated flowers. The change in ratio is very highly significant, Chi square = 27.49, (1 degree of freedom [df]). Values are sums of the numbers in the relevant quarters of Table 3, excluding the fruit (Fr) values. Chi square is a test for associations. It does not test for differences. Sweet vernal-grass *(Anthoxathum odoratum),* downy oat-grass *(Avenula pubescens),* spring-sedge *(Carex caryophyllea),* glaucous sedge *(Carex flacca),* bulbous buttercup *(Ranunculus bulbosus),* germander speedwell *(Veronica chamaedrys),* and heath speedwell *(Veronica officinalis)* have their main flowering period in June on the machair and/or the dunes and are shown with names in bold in Table 3. Dandelion (*Taraxacum* species) and field wood-rush (*Luzula campestris*) were in fruit (i.e. flowering had finished) on the machair on 4 June, as was heath wood-rush (*Luzula multiflora*) on the dunes. Spring sedge (*Carex caryophyllea*) was recorded vegetatively from three quadrats on the machair and spring squill (*Scilla verna*) from six on the machair. Both may have flowered before floral recording began. Common centaury (*Centaurium erythraea*), common bird's-foot-trefoil (*Lotus corniculatus*) and crested dog's-tail (*Cynosurus cristatus*) on the machair; and lady's bedstraw (*Galium verum*) on the dunes all show a clear peak in flowering in the 5x5m plots and are indicated with their maximum values bold and underlined in Table 3. Harebell (*Campanula rotundifolia*) was in bloom on

the machair from August onwards. The other plant which flowered late in the season on the machair, selfheal, (*Prunella vulgaris*) commenced flowering on 5 July on the dunes.

Count of species in bloom

Twenty one species flowered on the dune plots and 26 on the machair. The total number of plants at both sites pooled was 32. Six species only produced blooms in the dune plots, and 11 only in machair, 15 flowering at both sites, these are labelled D+M in Table 3.

The greatest number of species in bloom occurred on 5 July (day 187) on the machair (n=20) and on 5 July plus 17 July (day 199) on the dunes (n=16), (Table 3, row labelled 'Count flowering'). Values were pooled over all plots in both cases. The same trend is shown for those 15 species which flowered on both dune and machair (Table 4, first two rows). Members of the grass family had a clearly defined peak of five species in bloom on machair on 5 July and a broader peak of six on the dunes on 24 June (day 175) and 5 July, i.e. they followed the trend for all species. For 15 species which flowered on both dune and machair, more were in bloom on the dunes on three occasions (pooled over all 5 plots) and more on the machair on one occasion. On three dates there were equal numbers on both stand types (Table 4).

Pattern of flowering on a 'species-per-plot' basis

The third data row of Table 3 shows the mean number of species in bloom per plot (sum/5). The maximum is on 5 July for machair and 5 July for dunes.

Comparing flowering on a 'plots-per-species' basis

The mean number of plots with species in bloom on each visit is shown on the bottom data row in Table 3. This parameter is the mean of the values in the columns in the body of the table. It treats each species as equivalent to every other species. The theoretical maximum value is five. The highest value on the machair was 3.9 on 4 August and on the dunes was 4.0 on 23 August, i.e. approximately one month after the highest overall number of species in bloom (machair n=20, 5 July; dune n=16, 5&17 July). Later in the season it is mainly the commoner species which are still in bloom. The rare species, occurring in a few plots, tend to be earlier flowering. Hence high values of this parameter occur late in the season.

The overall mean number of plots with species in bloom (pooled over all visits) on the machair was 3.45 (n = 100 records) and on the dunes (n=81 records) was 3.58. The two values are not significantly different at the 5% level using the z test for differences, z = 0.53. Thus there was no *difference* in mean flowering abundance between dune and machair, using this parameter. 3.45 is close to 3.47, the mean of seven values in the bottom data row in Table 3 for dunes; and 3.48 is close to 3.55. The differences are due to rounding errors.

Fifteen species occurred on both dune and machair. They were generally the more widespread species. For these fifteen there were high values on machair on 17 July, 4 & 23 August. (Table 4, row labelled 'Plots-per-species - mean'). The highest value on the dunes (3.9) was on 24 June, when the value on the machair was 4.0.

The median value of this parameter for the fifteen species and for all seven visits was 4.0 (mean 4.2) for machair and 3.5 (mean also 3.5) for dunes (Table 4).

For each visit (n = 7), the machair value was greater than the dune value. The data are paired a) in time and b) in plot layout and are assumed to be non-parametric. Under these circumstances, as all pairs show increases from dune to machair, with no decreases and no equal values, one can safely conclude that the two sets of data are different without undertaking a statistical test, see 'Statistical note' in Methods section. Had there been one or more equal values, or a change in direction, a Wilcoxon test for differences would have been performed.

The degree of difference between the dune value and machair values varies appreciably over time. The median increase from dune to machair, as a percentage of the dune value, is 17.2% (average 19.9%).

In summary there is a consistently higher value of the parameter 'plots-per-species' for machair compared with dunes for the fifteen species common to both.

Comparing the number of visit periods when plants were in bloom

The 'Total F' columns in Table 3 shows the number of visit periods when plants were in bloom. There was no significant difference in this parameter between machair and dune (Mann Whiney U Test, U = 254, P<0.05). The median for the machair was 3.5 (n=26 species) and for the dunes the median was 4.0 (n=21 species). For insect pollinated species there was no significant difference between dune and machair in the number of visit periods when plants were in bloom (U = 94, P<0.05). Similarly for wind pollinated species there was no significant difference (U = 25.5. P<0.05); see also the sub-section ***General pattern of flowering*** for an analysis based on associations. The overall mean number of plots with species in bloom on the machair was not significantly different from that on dunes (see ***Comparing flowering on a 'plots-per-species' basis*** sub-section). These analyses treat each species as equivalent to every other species.

The component elements of the total set of records (n=635) was analysed using Chi square for *associations*. Forty two per cent of the records (n=345) were contributed by the five species which flowered for all seven periods in the machair, shown boxed in the body of Table 3. Twenty one percent of the records (n=290) were contributed by the two species that flowered for all seven periods on the dunes. This change in ratio is very highly significant, Chi square = 32.82, (1 df).

Belted beauty moth

The caterpillars of the belted beauty moth (*Lycia zonaria*) were observed on both dune and machair plots.

DISCUSSION

Allocation to National Vegetation Classification (NVC) plant community and sub-community

In plant community studies, abundance over a set of samples is often measured in five constancy classes I 1-20%; II 21-40%; III 41-60%: IV 61-80%; V 81-100% (Kent *et al.*, 2003): (NB Rodwell, 1992 & 2000, describing all samples from England, Scotland and Wales, uses 'frequency' or 'frequency class' for this attribute). The higher constancy values i.e. III, IV or V for the whole SD8 in Britain, taken from Rodwell (2000), are shown for the species in Table 3. These are key components of the SD8. (Values of II and I are shown in Rodwell (2000), but not in Table 3). Nine of the species of the bloom on dune and/or machair (overall n=32) had a national (England, Scotland and Wales) constancy value III, IV or V in the SD8. Of these 9, daisy (*Bellis perennis*) was only in bloom on the machair (five plots); and marram grass was only in flower on the dunes (four plots). All other seven species flowered on both dune and machair. Daisy was found in all the six 2x2m quadrats and the 1x1m quadrat on the machair but was absent from the quadrats on the dunes. Marram grass showed the symmetrically opposite trend. On Colonsay and Islay it is often the case that few individual marram plants within a stand will flower in any one year. Nine of the 32 species in bloom had a constancy of III or more in the MG5 (Rodwell, 1992), i.e. the unimproved, mesotrophic grassland community, demonstrating a linkage between the MG5 and the SD8. Making the comparison the other way round, of the 36 species in bloom in a stand of MG5 in Yorkshire consisting of four 25m^2 plots, eight had a constancy of III or more in the national SD8 (Gulliver, unpublished). Fourteen species of vascular plant have a constancy of III or more in Britain as whole in the SD8 and 22 in the MG5.

In the surveys of dune and machair in Scotland undertaken by Dr T. Dargie, constancy values for the SD8d and SD8e sub-communities were found to be different from those for sand dune communities in Britain as a whole (Angus 2001, p. 207; Kent, *et al.*, 2003). For plants in bloom in the *plots* on Colonsay, ten had a constancy of III or more in the national NVC SD8d and 14 in the national NVC SD8e. For the component species of the 2x2m *quadrats* in dune and machair, national NVC constancy values were compared with those provided specially for the machair, based on the work of Dr T. Dargie. Under both systems the dune quadrats and the machair quadrats were slightly closer to the SD8e, the clearest differentiation occurring for the machair quadrats using the Dargie values. However the national SD8e has 23 species of vascular plant with constancy of III or more whereas the national SD8d has 13. Hence there are more opportunities for matches to be made with the SD8e than with the SD8d. (This should also be born in mind when interpreting the plot data). For the Dargie values there is a lesser difference, 14 species of vascular plant have a constancy of III or more with the SD8d, 17 with the SD8e.

It is likely that on Colonsay species tolerant of continuous grazing were strongly favoured, and taller plants such as meadow buttercup (*Ranunculus acris*) disfavoured. Under a lighter grazing regime, or one with grazing breaks, a fuller range of species may well be present and preferences for degrees of soil wetness would be more evident. The SD8e is normally associated with damper sites (Angus, 2001; Kent *et al.* 2003). In summary, tolerance for heavy grazing appears to have been ecologically more important than preferences for soil condition, and plant sub-communities are therefore not clearly defined.

There were major differences in height and structure of the vegetation structural dune and machair, yet both belonged to the same NVC plant community (SD8). Fifteen species flowered in both stand types, 11 only in machair and six only in dune. These differences emphasise the need for gathering a range of data, and especially vegetation height, when conducting vegetation surveys.

Differences between dune and machair

The mean number of 'plots-per-species' (maximum value five) was greater on the machair at each visit for the 15 species which were common to dune and machair (Table 4). This parameter treats each species as equivalent to every other species. The difference was variable, and the mean difference for the seven dates was moderate in size; the overall median for all seven dates for machair was 4.0 and dune 3.5.

For the 2x2m quadrat data there was an absolute difference between machair; median 23, range 22-25, species per 4m^2; and dune, median 15, range 12-17 species per 4m^2.

Hence differences between dune and machair were revealed using both these parameters. Vegetation height was also different between the two stand types. However there was no clear-cut differentiation for the mean number of species in bloom per plot (Table 3).

Heavy grazing in relation to taller dune and machair plants

Observation indicates that generally meadow buttercup (*Ranunculus acris*) and lesser meadow-rue (*Thalictrum minus*) are avoided in lightly grazed dune and machair, but are consumed under heavy grazing regimes. Both have a constancy of III in the SD8. *Ranunculus* species contain protoanemonin (a product of hydrolysis of the toxic glucoside ranunculin); *Thalictrum* species contain protoanemonin or a related substance (Cooper & Johnson, 1984). Neither was recorded flowering, and neither was present in the 2x2m quadrats. Neither was present in the 25x25m reference area containing the machair plots; lesser meadow-rue was present in the

25x25m reference area eontaining the dune plots. Ragwort (*Senecio jacobaea*) contains several pyrrolizidine alkaloids which are poisonous (Cooper & Johnson, 1984). It is grazed by sheep, but not by rabbits or cattle. On dune systems with rabbits and cattle (but no sheep), it is especially favoured by high grazing levels (Angus, 2001). On dune systems with rabbits, cattle and sheep; it is favoured when sheep numbers are low. It was not recorded flowering in the dune or machair plots. It was present in one of the machair 2x2m quadrats (vegetation height 1cm). It has a constancy of III in the SD8. Meadow buttercup and lesser meadow-rue have been recorded in the two 1x1km squares (monads) containing the plots. Ragwort has been recorded in the monad containing the dune plots. The plant heights given in Clapham *et al.,* (1987) are meadow buttercup 15-60(100)cm, lesser meadow-rue 15-150cm, and ragwort 30-150cm. It appears that the heavy grazing regime, producing sward height of 1cm on the machair, is precluding these moderately tall plants of the SD8, despite their varying degrees of unpalatability/toxicity. The toughness of the leaves of marram grass renders it unpalatable. Huiskes (1979) states "Grazing of *Ammophila arenaria* by sheep and cattle has been observed, but the species is avoided if there are other alternatives". It was absent from the heavily grazed machair quadrats at the study site, though it is present in somewhat less heavily grazed machair on Colonsay. Twelve species of inseet have been recorded feeding on marram grass (Huiskes, 1979).

Further consequences of the continuous grazing regime

The clumps of marram grass provided structural niches for potential use by invertebrates and ground nesting birds, these niches were absent in the machair. Dowdeswell (1981) states that grass tufts have a distinct microclimate which is different to the macroclimate above. He found that the presence of ants, slugs and snails in grass tufts proved to be a good indicator of the activity of the larvae of the meadow brown butterfly (*Maniola jurtina*). On these Colonsay dunes the sward between the marram clumps was taller than the single sward layer on the machair (Table 2). Meadow pipits (*Anthus pratensis*) and skylarks (*Alauda arvensis*) were present above the plots. On the uniform machair insects visiting flowers for nectar or pollen would be able to move from one flower to the next more readily. A greater percentage of the plants in bloom were insect pollinated on the machair, compared with the dunes. In the dunes the zones between the marram clumps may well provide areas of still air with a warmer microclimate.

The period over which many plants were in bloom was long in both areas. This is believed to be due to the continuous grazing regime removing upward growth and promoting lateral growth, some of which bore flowers. In the well-studied plant ragwort, mowing resulted in an initiation of buds on the surviving stem or from the crown i.e. where the stem meets the roots, (Harper & Wood 1957; p.624 & 626). Flowering and seed set oceurred e. 10 weeks later than uncut plants.

Flowering peak

The peak of overall number of species in bloom was in early July in the machair and both early and mid July in the dunes. In unmanaged, tall grassland on clay on the Yorkshire coast, peak flowering occurred between late July and early August (Gulliver, 1988). A group of species which finished flowering ahead of the main peak occurred in the Yorkshire and Colonsay studies.

Nature of recording the phenomenon of flowering

In this study, flowering was recorded as presence/absence. In further studies the abundance of flowering within plots could be investigated with advantage. Such investigations may reveal extra aspects of this system. It is, for example, possible that the number of individual plants in bloom per plot would be greater on the machair, but the number of flowers per plant would be greater on the dunes.

Visitor interaction with dune and machair

Humans can traverse the maehair more easily than the dunes. Eleven plant species were in bloom on the machair but not on the dunes; and five on the dunes but not in the machair, in the study plots. Colourful, insect pollinated flowers represented a greater percentage of the plants in bloom on the machair. Hence on first acquaintance the machair may hold greater interest to the visitor and naturalist. Such conclusions could be complemented by studies at a larger scale, by interviews or by questionnaires. Parallel trends in levels of natural history interest may exist among invertebrates. Preliminary observations suggest that the caterpillars of the belted beauty moth, a United Kingdom Biodiversity Action Plan (UK BAP) species occur on both dune and machair on Colonsay as a whole. However it is on the machair that they are more readily observed and hence appreciated by human visitors.

Within the dunes niches with reduced grazing levels may allow seed set for plants, protection from consumption for invertebrates, and refuges from trampling for nesting birds. Hence the dunes may have an important role in maintaining plant and animal populations, which disperse over dune and machair; the component individuals being more visible on the machair.

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Appendix 1: Notes on references

Angus, S. (2006) is an enlarged version of Angus, S. (2004). De Tha Machair? Towards a Machair Definition.
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Anon. (1999a) and Anon. (1999b). The web pages carry a note at the top that the Habitat Action Plans date from 1995-1999. However on downloading this material from the web the date of the year of download is generated.

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No address is given for the Joint Nature Conservation Committee. The address given in the publication is that of the author at Dornoch, Sutherland.

			Scale			
			$1m^2$	$4m^2$	$25m^2$	$125m^2$
		Single or median	S	S	M	S
Plants in bloom	Machair	value	**6**	**6**	**10**	**14**
All values						
17 July	Dune	value	**5**	**5**	**12**	**16**
		Single or median	S	M	S ($6x4m^2+1x1m^2$)	S
Presences	Machair	value	**22**	**25**	**33**	**36**
All species		date	[17:07]	[5:07]	[5&17:07C]	[06&07C[a]]
Dates as shown	Dune	value	**14**	**15**	**22**	**26**
		date	[17:07]	[24:06]	[24:6&17:07C]	[06&07C[a]]

Table 1. The number of plants in bloom on 17 July 1992 at different scales. The number of species presences at different scales are additionally shown, 17 July for $1m^2$; single or component dates as indicated for $4m^2$, $25m^2$ and $125m^2$. S = single quadrat or plot, M = median value of 5, C = composite value; component quadrats or plots in the sample recorded at different, but single, dates.
Note [a] component dates for 06&07 - 4:06, 24:06, 5:07, 17:07.

	Vegetation height (cm)				
	June		**July**		**Sep.**
	4	24	5	17	19
Machair	1	1	1	1	1
Dune					
Lower Layer	5[a]	5	5	4	3
Middle Layer	5[a]	13	14	14	12
Upper Layer i.e. Marram grass	40	50	50	50	60

Table 2. Vegetation height (cm) in five 5m x 5m plots on dune and machair on Colonsay on five dates. Figures are the values of recording unit used, nearest to the arithmetic mean.
Note [a] Lower Layer + Middle Layer not differentiated on 4 June.

SPECIES	NVC	D	Machair (M)								Dune (D)							
Bold species names	SD8	&/or	June		July		Aug		Sep	Total	June		July		Aug		Sep	Total
= mainly June flowering		M	4	24	5	17	4	23	19	F	4	24	5	17	4	23	19	F
Day number (leap year)			**156**	**176**	**187**	**199**	**217**	**236**	**263**	n=26	**156**	**176**	**187**	**199**	**217**	**236**	**263**	n=21
Insect pollinated																		
Taraxacum species		M	2Fr															
Veronica officinalis		M	1							1								
Veronica chamaedrys		D+M	5							1	5	4	1	1				4
Ranunculus bulbosus		D+M	5	5	1					3	3		1					2
Lotus corniculatus	IV	D+M	1	**5**	3	4	2			5	5	5	4	4	4	4	1	7
Coeloglossum viride		M		1	2	1				3								
Galium verum	V	D+M		2	5	5	4		1	5			2	**5**	2			3
Trifolium repens	IV	D+M		2	2	5	5			4		4	4	5	5	5		5
Centaurium erythraea		M		2	3	**4**	2	1	1	6								
Leontodon taraxacoides		M		2	1	1	5	2	1	6								
Linum catharticum		D+M		5	5	5	5	5	5	6				1				1
Pilosella officinarum		M			1	1	1	1		4								
Campanula rotundifolia		M					2	3		2								
Prunella vulgaris		D+M					5	5	5	3			5	4	5	5	5	5
Bellis perennis	III	M	5	5	5	5	5	5	4	7								
Polygala vulgaris		M	5	1	1	1	4	2	1	7								
Cerastium fontanum	III	D+M	1	1	5	5	5	5	5	7	1	1		1		1		4
Euphrasia nemorosa		D+M	4	5	5	5	5	5	5	7	4	5	5	5	5	5		6
Thymus polytrichus		D+M	5	5	5	5	5	5	5	7	4	5	5	5	5	5	4	7
Gentianella amarella		(M)						B										
Crepis capillaris		D										4	4	5	5	5	4	6
Wind pollinated																		
Luzula campestris		M	5Fr															
Luzula multiflora		D									5Fr							
Carex caryophyllea		M	2							1								
Carex flacca		D+M	5							1	2	2						2
Anthoxathum odoratum		M	3	2	2					3								
Poa humilis	IV	D+M	3		1					2	2	4	2	3	2	1		6
Plantago lanceolata	V	D+M	5	5	5				1	4	3	3	3	2	1			5
Koeleria macrantha		D+M		5	5	5				3		5	5	5				3
Cynosurus cristatus		M			**4**					1								
Festuca rubra	V	D+M			1					1		5	5					2
Avenula pubescens		D									3	1						2
Poa trivialis		D										2						1
Holcus lanatus		D										5	5	5	5	5	1	6
Agrostis stolonifera		D											2	1				2
Ammophila arenaria	III	D											4	4				2
										mean								mean
Count flowering			14	16	**20**	14	14	11	11		10	15	**16**	**16**	10	9	5	
Count flowering grasses (n=11)			2	2	**5**	1	0	0	0		2	**6**	**6**	5	2	2	1	
Mean no. of species F per plot (sum/5plots)			10.0	10.6	**12.4**	10.4	11.0	7.8	6.8		6.4	11.0	**11.4**	11.2	7.8	7.2	3.0	
										n=7								n=7
Mean plots-per-species			3.6	3.3	3.1	3.7	**3.9**	3.5	3.1	3.47	3.2	3.7	3.6	3.5	3.9	**4.0**	3.0	3.55

Table 3. Sequence of flowering (F) of twenty six species on machair (M) and of twenty one species on dune (D) in five 5m x 5m plots on Colonsay. Values are number of plots with the relevant species in bloom. Clear peaks in body of table - bold and underlined. Max value in numerical summary - bold. Fr - in fruit. Insect pollinated F n=19, plus *Gentianella amarella* Bud (B) only. Wind pollinated F n=13. NVC SD8 for details see text.

		June 4	24	July 5	17	Aug 4	23	Sep 19	Mean of 7	Median of 7
Count of species	Machair	9	10	**12**	8	8	5	7	8.4	8.0
	Dune	9	11	**12**	**12**	8	7	3	8.9	9.0
Plots-per-species - mean	Machair	3.8	4.0	3.6	4.9	4.5	**5.0**	3.9	4.2	4.0
	Dune	3.2	**3.9**	3.5	3.4	3.6	3.7	3.3	3.5	3.5
Difference in values of plots per species: all show increase D to M	Number	+0.6	+0.1	+0.1	+1.5	+0.9	+1.3	+0.6	+0.7	+0.6
	% of D	17.2	2.3	2.4	42.7	24.1	34.6	17.0	19.9	17.2

Table 4. The number of species recorded in bloom at each of seven dates and the number of plots per species for the 15 species common to dune (D) and machair (M).

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The dangers of lion's mane jellyfish *Cyanea capillata* (Linneaus) to domestic dogs *Canis lupus familiaris*

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ABSTRACT
Jellyfish are frequently stranded on coastlines around the United Kingdom towards the end of summer. At least one species in Scotland has a potential health risk. The lion's mane jellyfish *Cyanea capillata* (Linneaus) becomes stranded on Scottish beaches during summer and autumn. I describe a specific incident that illustrates the danger of stranded specimens of this species to dogs. No other incident in which dogs have been stung by jellyfish under field conditions appears to have been recorded in the literature. Dog owners are advised not to allow their dogs to come into contact with stranded jellyfish on the beach, or to allow their dogs to swim in the sea at that time.

INTRODUCTION
Jellyfish are common around the coasts of Britain as important members of the plankton during most of the year (Russell, 1953, 1970; Gibson et al., 2001). Their recent geographical distribution has received considerable attention (Mills, 2001; Parsons & Lalli, 2003; Doyle et al. 2007; Purcell et al 2007). In summer and autumn, jellyfish are often stranded on intertidal beaches in Britain (Houghton et al. 2007). The health risks of strandings are the bodies of the jellyfish and the stinging cells (Rice & Powell, 1972; Heeger et al. 1992; Colin & Costello, 2007). The stinging cells are used by live jellyfish to catch food and also as a defence mechanism. Nematocysts can remain active for some time after the death of an individual. This means that dead jellyfish stranded in the intertidal zone will still retain active nematocysts. The lion's mane jellyfish *Cyanea capillata* (Linneaus) regularly becomes stranded on Scottish beaches during summer and autumn. Many individuals are often stranded at the same time. Kames Bay and West Bay, Millport, Isle of Cumbrae, Firth of Clyde, is regularly affected in this way. Fig. 1 illustrates a recent stranding of *Cyanea capillata* in the upper intertidal and supra-littoral fringe at West Bay. In this paper I record two dogs being badly affected by coming into contact with the nematocysts of dead *Cyanea capillata* stranded on Kames Bay, Millport, Isle of Cumbrae. As a result of the episode, I advise all dog owners to keep their dogs away from beaches where jellyfish strandings are present. Dogs should also be restrained from swimming in the sea at this time, as living jellyfish are likely to be even more dangerous to dogs.

Fig. 1. Two moribund specimens of *Cyanea capillata*, one (foreground) on grass in the supralittoral zone and the other (middle distance) on coarse sand at the top of the intertidal zone, West Bay, Millport, Isle of Cumbrae, Firth of Clyde, Scotland. Photograph by Professor Geoff Moore, University Marine Biological Station, Millport.

Case history
In autumn some years ago, I was collecting intertidal sediment and invertebrate infauna on Kames Bay, Millport, Isle of Cumbrae. I had with me two German Shepherd dogs that stayed close to me while I was collecting on the beach. I had noticed a large number of brownish jellyfish stranded on the sand in the intertidal zone that I identified as *Cyanea capillata*. The jellyfish were still fairly fresh, as when I accidentally trod on one it felt turgid. The dogs spent time sniffing around the jellyfish, pawing some of the tentacles and bodies. This continued over about 45 minutes while I was collecting. Towards the end of my

collecting I noticed that the dogs were limping slightly, and in some discomfort. I finished collecting, and took the samples and the dogs back to the vehicle. At this point the dogs began to lick their paws, and then to retch. I had water for the dogs with me, but was unable to persuade the dogs to drink. Their discomfort became rapidly worse as I left Kames Bay with them in the car. The dogs were continuously retching, and obviously in extreme discomfort. I stopped once on the journey, about three miles out of Largs. I persuaded the now very ill dogs to get out of the vehicle and attempted to get them to drink some milk and also to eat grass. Both stratagems failed – although they did make attempts to drink milk but vomited. This proved to be the peak of their suffering as their retching and vomiting progressively declined as we reached Glasgow University one hour later, and on arrival I was able to provide the two dogs with a soft blanket in my office. They were completely exhausted. After some hours I was able to take them home, where they recovered over a twelve-hour period, returning to their normal behaviour after 24 hours.

DISCUSSION

The ecology of the lion's mane jellyfish *Cyanea capillata*

The ecology of *Cyanea capillata* is well documented (Russell, 1970; Calder 1971; Rice et al. 1972; Mills, 2001; Doyle et al 2007; Higgins et al 2008). The species is a cold water one, and lives for about one year. Towards the end of their life in late summer or autumn, groups of individuals are common in nearshore waters, often being stranded on sandy and muddy beaches in northern Britain. The jellyfish whose nematocysts stung the dogs was the lion's mane jellyfish *Cyanea capillata*. Individuals are usually brown or orange (Russell, 1970), and range in size from a bell diameter of 20 cm to a bell diameter of 40 cm in the Clyde Sea. The tentacles of *Cyanea capillata* bear stinging cells, or nematocysts, on them (Rice & Powell, 1972; Mariscal, 1974; Tardent & Holstein 1982; Colin & Costello, 2007; Higgins et al 2008). There is a wide range of studies on the effects of jellyfish stings on mammals including man (Heeger et al 1992; Peca et al 1997; Veraldi & Carrera, 2000; Haddad et al 2002; Boulware, 2006). Surprisingly, there appears to be only one report on the effects of jellyfish stings on dogs (Hastings et al 1967). This study tested the effects of the nematocyst toxin of the Portuguese man-of-war *Physalia physalis* on eight mongrel dogs after intravenous administration. Within one minute of injection of low doses there were major changes in the electro cardiograms of the dogs. Higher doses led to cardiovascular collapse.

The case history reported above

My field observations on the dogs make it clear that their paws had been stung by nematocysts, and that the dogs had then licked their paws to get rid of the sting. Some of the poison or perhaps unexploded nematocysts must have then entered their throats, making the dogs retch and vomit. The implications of this and similar episodes for dogs are potentially very dangerous. When lion's mane jellyfish *Cyanea capillata* are stranded on the beach there are likely to be many individuals in the water close to the beach. This is the area where dogs often swim. Any dog that swims into *C. capillata* will immediately be stung around the face including the nose, eyes, and mouth. The genital regions and paws are also likely to be particularly affected. Tentacles of *C. capillata* will also become caught up in the dog's fur. Clearly the situation will cause the dog extreme pain, and could cause death by panic drowning or by the subsequent effect of the nematocyst poison. Surprisingly, there appear to be no similar reports if such field events in the veterinary literature. When *C. capillata* are stranded on the shore dogs should not be allowed on to the shore.

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Freshwater plants and their distribution on the Clyde island of Great Cumbrae

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ABSTRACT

Freshwater plants were recorded on the Island of Great Cumbrae between 2003 and 2009. Ordination analysis (detrended correspondence analysis) showed that there were freshwater plant communities that were characteristic of (1) upland lochans, (2) early twentieth century reservoirs and (3) the fen-like abandoned wet pastures of the raised beach that encircles the island. Mean Ellenberg's indicator values for Reaction (R) and Nitrogen (N), respectively indicators of site pH and fertility, suggested that, in general, the lochans were most acid and least fertile while the early twentieth century reservoir sites were least acid and most fertile, and the raised beach sites were intermediate. There were, however, anomalies; (1) two lochan sites had freshwater plant communities that were more similar to the reservoir or raised beach sites than to other lochans, and their mean Ellenberg's R and N values suggested that they were less acid and more enriched than the other lochans, (2) a small quarry pool on the raised beach that had an idiosyncratic flora including casual and recently introduced species, and (3) the wet pasture of the raised beach on the east of the island that was grazed by cattle and was species-poor in freshwater plants. No vascular freshwater plants that are rare or scarce in Britain were found, although a stonewort that is nationally scarce in the UK (*Nitella flexilis*) was recorded. The botanical conservation value of the freshwater plants on Great Cumbrae lies, therefore, more within the entirety of their communities rather than in any individual species. It is suggested that potential threats to the freshwater plant communities are (1) benign neglect of sites that no longer have a water-supply or economic/agricultural function, and (2) eutrophication brought about by change in land use.

INTRODUCTION

The publication of a new flora for Great Cumbrae (Hannah, 2008) is likely to promote interest in the plants and vegetation of the island. The flora makes extensive use of Hannah's own field recording and also draws upon the wealth of previously published work about plant records and vegetation on the island. This work includes classical ecological descriptions of vegetation types (Sutherland, 1926), comprehensive plant lists with ecological context (Fletcher & Martin, 1960; Rhind, 1988), notes on pteridophytes (Merryweather, 2000), an account of how students addressed the phytosociology of upland heath (Goulder & Scott, 2006), and records made by a field meeting of the Botanical Society of the British Isles (Hannah, 2007a). The present article adds to previous knowledge by providing information on freshwater plants and their distribution on Great Cumbrae from observations and records made in June or July of 2003 to 2009.

FRESHWATER SITES ON GREAT CUMBRAE

Great Cumbrae is an island in the Firth of Clyde, Scotland, within Watsonian vice-county 100 (Clyde Isles). The island has an area 12.6 km^2 and maximum altitude 127 m and is described by Campbell (2004). The geology (Cameron & Stephenson, 1985) is largely sedimentary. The predominant underlying rock is Upper Devonian old red sandstone and there is an area of Carboniferous calciferous sandstone in the south of the island; igneous intrusions form dykes that are, sometimes-conspicuous, landscape features. Land use is largely livestock farming; the vegetation is mostly upland heath and grassland, and improved pasture. The island has only about 7% tree cover which consists of probably nineteenth and twentieth century mixed plantings, twentieth century coniferous plantation, and semi-natural woodland on old sea cliffs. The principal settlement is the resort town of Millport at the south of the island. Great Cumbrae has no substantial natural standing freshwaters nor rivers, the lack of adequate supply of freshwater being historically an ongoing problem for the human population (Campbell, 2004).

There are artificial lochans on the island, several of which no longer have free-standing water but are colonized by emergent freshwater plants rooted in the waterlogged substratum. Most of the lochans are upland and are largely clustered around the centre of the island at altitudes between about 70 m and 110 m. In general, they were made or enlarged by construction of dams and have catchments of heath or upland grassland.

The areas of freshwater sites were determined using 1:1800 scale maps printed from EDINA Digimap (http://digimap.edina.ac.uk) and are approximate.

Freshwater plants were recorded at the following lochan sites.

Site a. Minnemoer (National Grid Reference NS 169 570); the largest of the lochans, with cattle-trampled margins and opaque brown peaty water, area 0.90 ha, lies close to the centre of the island and within 150 m

of the Glaid Stone, the highest point on the island. The 1856 Ordnance Survey shows two adjacent small water bodies; by the 1895 survey the water level had been raised by construction of a bank to form a single body of water. Freshwater plants were recorded in both the lochan and its boggy outflow channel.

Site b. Wee Minnemoer (NS 168 567); about 150 m south-west of Minnemoer, present during the 1856 survey and latterly used as a curling pond. This lochan contained water in April 2003 but by July that year the masonry dam no longer held water, leaving a damp flat-bottomed basin, area 0.41 ha, with shallow free-standing water only at the western end adjacent to the dam and less than about 10 cm deep.

Site c. A lochan (NS 170 568) unnamed by the OS, about 100 m south-east of Minnemoer, constructed between the 1856 and 1895 surveys. The red sandstone dam was long broken-down by 2003, the bed of the lochan, 0.15 ha, being boggy and without free-standing water except for about 1-2 m^2 of shallow water immediately adjacent to the dam.

Site d. A lochan (NS 172 568) unnamed by the OS, about 300 m south-east of Minnemoer, area 0.23 ha, comprising an excavated basin with water retained by a dam of earth and stones; it was not recorded by the 1895 survey. The water is opaque, brown and peaty and the margins are cattle trampled.

Site e. A pair of adjacent, unequal-sized lochans (NS 173 573), 0.17 ha and 0.03 ha, unnamed by the OS, about 400 m north-east of Minnemoer, constructed by building of dams between the 1856 and 1895 surveys. The water is brownish but moderately clear; there is much overgrowth by emergent aquatic vegetation. There was extensive planting of broad-leaved trees in the catchment of these ponds between June 2006 and June 2007.

Site f. Davy's Dub (NS 179 559), an outlying lochan about 1500 m south-east of Minnemoer, recorded by the 1856 survey. The lochan is a shallow, regular rectangular basin, area 0.09 ha, lying parallel to the contours of a north-facing slope, possibly dug out or enlarged to provide a water supply although there is no obvious dam; in June 2008 the bed of the lochan was waterlogged but without free-standing water.

Site g. Loch Leech (NS 153 550), a damp basin with no free-standing water, area 0.35 ha, possibly originally excavated; shown by the 1856 survey as a marshy basin, omitted from the 1895 survey but marked as a water body on modern maps. This is a lowland site in the south-west of the island; altitude 35 m, with a catchment of arable and improved pasture.

Two water-supply reservoirs were built on Great Cumbrae at the beginning of the twentieth century, the first in 1905 (Campbell, 2004). These reservoirs are in the south-west of the island, at low altitude (c. 50 m) and are linked by a narrow channel. They are now recreational amenity sites; they have deep relatively-transparent open water, are much used by anglers, and are surrounded by a golf course. The water treatment plant has been dismantled; water supply from the Ayrshire mainland became available in the late twentieth century. Freshwater plants were recorded at the following early twentieth century reservoir sites.

Site h. Upper Cumbrae Reservoir (NS 161 562), area 1.81 ha.

Site i. Lower Cumbrae Reservoir (NS 159 560), area 2.94 ha.

Site j. Reservoir outflow channel; an engineered straight watercourse, about 1 m wide and with summer base-flow water depth about 5-10 cm. The channel extends from Lower Cumbrae Reservoir for about 250 m across the golf course to Upper Kirkton; it then becomes the Mill Burn which flows roughly southwards, for about 1000 m to Millport, alongside a road and across gardens and small fields, much of the channel being straightened, culverted and inaccessible.

Additional freshwater habitat on Great Cumbrae is to be found on the flat, raised beach that encircles the island, lying between the former sea cliffs and the present-day sea shore (Caldwell, 2004). Some of this raised beach is grazed but much is occupied by tall fen-like vegetation bounded on the seaward side by the 1875 circumferential coast road; the stock-proof fencing and gates suggest that this is abandoned pasture. This coastal wetland is liable to be fed by freshwater from the centre of the island that has run over the old sea cliffs or up-welled beneath them. Attempts at drainage have been made; there is usually a ditch on the landward side of the circumferential road and ditches at right angles have frequently been dug across the pastures although many of these have become silted up. Pasture and ditches form a mosaic much of which is colonized by aquatic freshwater plants, together with a great diversity of wetland plants. Freshwater plants were recorded at the following sites on the raised beach.

Site k. An area of abandoned tall-herb wet pasture, at the south-east of the island, that extends for about 250 m south-westwards from the Marine Biological Station (NS 175 545) and ditches around the Marine Biological Station.

Site l. Ditches and abandoned tall-herb wet pastures on the west of the island recorded at irregular intervals over about 3.7 km from south of Sheriff's Port to Skate Bay (NS 166 585).

Site m. A flooded quarry pool (NS 150 551), area 0.02 ha, and its immediate environs on the raised beach at the south-west of the island. This pool is cut into the red sandstone adjacent to the coastal road but apparently pre-dates the road, being recorded by the 1856 survey.

Site n. Ditches and cattle-grazed pastures on the east side of the island recorded at irregular intervals over about 1 km northwards from near Stinking Goat (NS 182 571) to the Boat Harbour.

THE DISTRIBUTION OF FRESHWATER PLANTS

Different methods can be used to record plants at freshwater sites.

(1) The vegetation can be recorded in its disparate parts; with this approach different homogenous stands

of vegetation are identified and their component taxa are recorded. Such stands might be, for example, distinct areas of floating-leaved or submerged vegetation of size perhaps 2m x 2m or 4 m x 4 m, or perhaps 1 m x 10 m linear strips of emergent fringing vegetation – this is the approach used by the National Vegetation Classification (Rodwell, 1995).

(2) A holistic approach can be adopted and plants can be recorded over the whole freshwater site. If this is done the recording of all taxa present may be attempted but this potentially leads to problems with defining the bounds of the site and requires extensive plant identification skills. Alternatively, only those taxa that are specifically regarded as being freshwater plants can be recorded. This solution needs a checklist otherwise there are problems over how to define freshwater plants (Goulder, 2008).

In the present study the aim was to record taxa that were deemed to be freshwater plants, over the whole of each freshwater site. The checklist used was Table 3 of Palmer & Newbold (1983) which is also available as electronic material supplementary to Goulder (2008). The Palmer & Newbold checklist comprised the 157 taxa that its authors considered to be the fully-aquatic freshwater vascular plant flora of Scotland; plants that these authors judged to be not fully aquatic, although riparian or wetland, were not included in this list. For the purpose of the present study, however, the checklist was augmented by the inclusion of additional species of *Juncus* and stoneworts (Characeae). Furthermore, all *Callitriche* species were recorded as a single category. Nomenclature followed Stace (1997) for vascular plants and Bryant *et al.* (2002) for stoneworts.

Freshwater plants were recorded by walking around the margins of lochans and reservoirs, and across the raised beach and the beds of lochans that lacked free-standing water. At some open-water sites a grapnel was used to retrieve plants; detached plant fragments that had washed ashore were also recorded.

There were obvious visual differences in vegetation between the freshwater sites on Great Cumbrae. Amongst the lochan sites, Minnemoer (site a) was largely open water and had submerged vegetation, principally *Myriophyllum alterniflorum*, and floating-leaved vegetation that was largely *Potamogeton gramineus*, *P. natans* and *Persicaria amphibia*. There was also emergent marginal vegetation, albeit cattle-trampled, within which *Eleocharis palustris* and *Equisetum fluviatile* were conspicuous. In contrast, at other lochan sites there was little or no free-standing water and the substratum was occupied by a more or less complete cover of emergent plants. At Davy's Dub (site f), for example, important species were *Carex rostrata*, *Juncus acutiflorus*, *J. effusus*, *Potentilla palustris* and *Ranunculus flammula*. The early twentieth century reservoirs (sites h and i) were predominantly open water and submerged plants were abundant, notably *Elodea canadensis*, *Littorella uniflora*, *Potamogeton berchtoldii* and *P. gramineus*. There were, however, some fringing emergent plants (e.g. *Eleocharis palustris*, *Equisetum fluviatile*, *Mentha aquatica*, *Persicaria amphibia*, *Sparganium erectum* and *Typha latifolia*) and occasional floating-leaved plants (*Persicaria amphibia* and *Potamogeton natans*). On the raised beach the vegetation of the abandoned wet pastures was in places dominated by wetland and emergent freshwater plants. For example, on the west of the island (site l), conspicuous within the up to 1 m tall herbaceous vegetation were *E. fluviatile*, *Iris pseudacorus*, *Juncus acutiflorus*, *Mentha aquatica* and, not on the Palmer & Newbold (1983) checklist, *Angelica sylvestris* and *Filipendula ulmaria*, while the ditch flora included *Apium nodiflorum*, *Baldellia ranunculoides*, *Rorippa nasturtium-aquaticum* agg., and *Ranunculus flammula*.

Fifty nine taxa were recorded that were on the augmented checklist; 14 of these were mostly found as submerged or floating-leaved plants while 45 of them were usually emergent (Table 1). Many species (26 taxa) tended towards ubiquity, being recorded at all three types of freshwater habitat; that is in the largely-upland lochans, the early twentieth century reservoirs and/or their outflow stream, and the raised-beach wetlands. These relatively ubiquitous species were almost all emergent plants; the exceptions being *Callitriche* spp. and *Littorella uniflora*, which were found both submerged and on mud, and the floating-leaved *Potamogeton natans*. Other taxa had a more restricted distribution. Seven species were recorded only at upland lochans; *Apium inundatum*, *Carex rostrata*, *Drosera rotundifolia*, *Lythrum portula*, *Veronica scutellata*, and the stoneworts, *Nitella flexilis* and *N. translucens*. Five taxa were recorded only at the early twentieth century reservoir sites; *Potamogeton berchtoldii*, *Equisetum palustre*, *Juncus inflexus*, *J. x kern-reichgeltii*, and the stonewort *Chara virgata*. Of these, the identification of *P. berchtoldii* was established by sectioning of young stipules (Preston, 1995); *J. inflexus*, a plant usually associated with base-rich soils, probably benefited from mortar in the dam of Lower Cumbrae Reservoir, while the *J. x kern-reichgeltii* record was a plant that had intermediate characters and was growing close to both parents, *J. effusus* and *J. conglomeratus*. Eight taxa were recorded only at the raised beach sites; *Lemna trisulca*, *Nymphaea alba*, *Alisma lanceolatum*, *Apium nodiflorum*, *Oenanthe crocata*, *Phragmites australis*, *Ranunculus sceleratus* and *Samolus valerandi*. The occurrence of *A. lanceolatum* in the flooded quarry pool (site m) is unexpected; the emergent plants, about six in July 2005, had leaves that were all lanceolate. The plants at this site were recorded as *A. lanceolatum* by a July 2007 BSBI field meeting (Hannah, 2007a) and were regarded as casual in vice-county 100 (Anon., 2008). *N. alba*, also in the flooded quarry pool (site m), was an introduction. Five plants present in June 2008, were not there the previous year; one that was in reach was still rooted in a pot-shaped clod of compost. These plants were surviving in June 2009.

The data in Table 1 were used to compare sites on the basis of species composition. This was done by detrended correspondence analysis (DECORANA) (Kent & Coker, 1994) using the Community Analysis Package (Pisces Conservation Ltd, Lymington, England). Fig. 1 shows DECORANA output; sites with similar plant communities are closer together. Five of the upland lochans (sites a-d and f) formed an evident cluster. Two lochan sites were atypical. Site e, the largely-overgrown unequal-sized pair of lochans, was put with the ditches and abandoned wet pastures of the raised beach (sites k and l). Loch Leech (site g) was put with the twentieth century reservoir sites (h-j), which were grouped relatively close together. The flooded quarry pool on the raised beach (site m) and the wet grazed pasture on the east of the island (site n) were outliers.

pH, CONDUCTIVITY AND BIOLOGICAL RICHNESS

Irregular determinations of pH and conductivity (compensated to 25 °C) were made on water samples from sites with free-standing water using appropriate pH and conductivity meters (Table 2). Samples were of surface water from the margins of the water bodies; measurements were made later on the day of sampling. pH values were all marginally acid and ranged from 5.6-6.7; there was no obvious pattern in pH related to type of water body. Values of conductivity ranged from 58-382 $\mu S\ cm^{-1}$. These values are an approximate indication of total concentration of dissolved minerals, and they may show local correlation with inorganic-nutrient status (Talling, 2009). The conductivity of the lochans (58-132 $\mu S\ cm^{-1}$) tended to be less than in the two twentieth century reservoirs (264-292 $\mu S\ cm^{-1}$). The quarry pool on the raised beach (site m) had the highest conductivity (382 $\mu S\ cm^{-1}$) probably because of sea spray.

Spot samples of pH and conductivity are, however, potentially poor indicators of long-term conditions. pH and/or conductivity fluctuate considerably within single water bodies (Wetzel, 2001). They are liable to change diurnally and seasonally, in response to photosynthesis and respiration of aquatic macrophytes and phytoplankton, and irregularly in response to rainfall, run off, and sea spray. They are also liable to show both vertical and horizontal variation within a water body; samples of marginal, surface water might not be representative.

An alternative approach for assessing pH and inorganic-nutrient status of freshwater sites is to use the composition of the plant community as an indicator. This approach has the advantage that plants are permanent inhabitants and therefore give an integrated, long-term, view of conditions at the site. Ellenberg's indicator values, as adapted for British plants by Hill *et al.* (1999), were used; specifically the indicator values for Reaction (R), which is an indicator for soil and water pH, and for Nitrogen (N) which is considered to be an indicator of general site fertility. Hill *et al.* (1999) allocated an R value and an N value to almost all native British plant species and to many introduced species. The indicator values are integers; values of R range from 1 (plants that are indicators of extreme acidity) to 9 (indicators of alkaline, often calcareous conditions) while those for N range from 1 (plants that indicate extremely infertile sites) to 9 (plants indicative of highly eutrophic conditions). The mean value of R and N at each site equalled the sum of the indicator values for all freshwater species recorded (Table 1) divided by the number of species at that site. *Callitriche* spp., *Juncus x kern-reichgeltii* and stoneworts were not used in the calculation of mean R and N values.

The mean R values (Table 2), based upon the whole freshwater plant community at each site, showed that there were marked between-site differences in pH and that these were related to the origin and/or nature of the sites. The results suggested that the lochans tended to be most acid; the range of mean R values for five of the seven lochan sites was 5.0-5.2. The exceptions, which had higher mean R values, were the two small reservoirs at lochan site e (mean R = 5.7) and Loch Leech (mean R = 5.6). The plants at the three twentieth century reservoir sites were indicative of less acid conditions (mean R values 5.7-6.0). The results for the coastal freshwater sites on the raised beach were more mixed. The fen-like abandoned pastures on the south-east (site k) and west (site l) of the island had plant communities indicative of relatively more acid conditions (mean R values 5.3 and 5.4) whereas the quarry pool (site m) and the wet pasture on the east of the island (site n) had plants that suggested less acid conditions with mean R values (6.0 and 5.6) that were similar to the twentieth century reservoir sites (h-j) and to the anomalous lochan sites (e and g).

The mean N values (Table 2) similarly suggested that there were between-site differences in inorganic-nutrient richness that were also related to the origin and/or nature of the sites. The plants at the lochan sites tended to indicate low nutrient status; mean N values at five of the seven lochan sites ranged from 3.4-3.8. The lochan site e (the two small reservoirs) was again anomalous (mean N = 4.3); the other anomaly was Loch Leech (site g) (mean N = 4.6). The plants at the three twentieth century reservoir sites indicated more eutrophic conditions and the range of mean N values was 4.3-4.9. These values were greater than at all of the lochan sites, except for the anomalous sites e and g. The mean N values for the sites on the raised beach mirrored those for mean R. The marshy abandoned pastures on the south-east and west of the island (sites k and l) had the lower mean N values (3.5 and 4.1) while the quarry pool (site m) and the grazed pasture on the east side of the island (site n) had higher values of mean N (4.7 and 4.4).

DISCUSSION

It is evident from DECORANA (Fig. 1) that the freshwater sites with different nature and origin that are found on Great Cumbrae had different communities of freshwater plants. Each type of site also tended to have

a characteristic pH and fertility regime; this was shown by the mean Ellenberg's indicator values for R and N (Table 2).

Five upland lochans (sites a-d and f) were put into a distinct cluster by DECORANA. The analysis also gave a species plot that is not included here but which indicated which taxa were associated with each cluster of sites (Kent & Coker, 1994). The taxa that were most strongly associated with the upland lochans' cluster were *Apium inundatum*, *Carex rostrata*, *Drosera rotundifolia*, *Eriophorum angustifolium*, *Lythrum portula*, *Nitella translucens*, *Potamogeton polygonifolius*, *Ranunculus hederaceus* and *Veronica scutellata*. These five lochans also had low mean Ellenberg's R (5.2 or less) and N (3.8 or less). Essentially these were upland sites, tending towards acid conditions and low fertility, with catchments largely of heath or unimproved grassland. Where free-standing water was present it was brown with high peat/humus content. An anomalous upland lochan site was the pair of small reservoirs (site e). DECORANA placed this site in the same cluster as the fen-like pasture sites on the raised beach (Fig. 1); freshwater plants that were recorded at this site but not in the other five upland lochans (sites a-d and f) were *Caltha palustris*, *Elodea canadensis*, *Myosotis secunda*, *Nitella flexilis*, *Rorippa nasturtium-aquaticum* agg. and *Veronica beccabunga*. Furthermore, this site (site e) had higher mean Ellenberg's R and N values (5.7 and 4.3 respectively) than the five other upland lochans. It is possible that this site has become more eutrophic due to the planting of broad-leaved trees in the catchment, presumably with added fertilizer. It is notable that *Lemna minor*, a species with high Ellenberg's R and N values (R = 7, N = 6) was not recorded in July 2003 but had become abundant by June 2007. Loch Leech (site g) was another anomalous lochan site; this was put by DECORANA into the same cluster as the early twentieth century reservoir sites (Fig. 1) and also had mean Ellenberg's R and N values (5.6 and 4.6) that were higher than those for all the other lochan sites except the anomalous site e. The anomalous, and more eutrophic, status of Loch Leech is readily explained by its lowland situation and catchment of arable land and improved pasture.

The three twentieth century reservoir sites (h-j) shared a similar freshwater plant community, being put relatively close together by DECORANA (Fig. 1). The plants most closely associated with this group were *Chara virgata*, *Elodea canadensis*, *Juncus inflexus*, *J. x kern-reichgeltii*, *Myosotis secunda*, *Potamogeton berchtoldii*, *Rorippa nasturtium-aquaticum* agg. and *Veronica beccabunga*. All the taxa that were found in the reservoir outflow channel (site j), except for *Glyceria fluitans*, were also recorded in one or both of the reservoirs and at least some probably originated as plant propagules carried downstream from the reservoirs. The early twentieth century reservoir sites also tended to be less acid and more nutrient rich than the lochans; this was shown by mean Ellenberg's R values (5.7-6.0) and N values (4.3-4.9) that were higher than at all the lochan sites except for the anomalous sites e and g. Potential contributory factors to the relatively rich nutrient status of the twentieth century reservoir sites are local soil and geological conditions and perhaps fertilizer application to the golf course that surrounds the reservoirs, and across which flow small feeder streams.

The two fen-like stretches of abandoned pasture on the raised beach (sites k and l) were placed close together by DECORANA (Fig. 1) and shared a cluster with the anomalous and probably enriched lochan site e. Freshwater plants that were found only at these raised beach sites were *Apium nodiflorum*, *Oenanthe crocata*, and *Samolus valerandi*. The mean Ellenberg's R values for these sites (5.3 and 5.4; Table 2) were higher than the mean R values for all the lochan sites apart from the anomalous sites e and g, but were less than the mean values for the twentieth century reservoir sites; hence conditions of intermediate pH were indicated. The mean Ellenberg's N values indicated that these sites were of intermediate richness. Thus the mean N values for both sites (3.5 at site k and 4.1 at site l) were less than at the early twentieth century reservoir sites, but were mostly greater than at the lochan sites, excepting the anomalous sites e and g. A probable source of enrichment at these sites is water from the top of the island that has become mineral enriched as it percolates down through the rock of the old sea cliffs and onto the raised beach. The raised beach at the south-east of the island (site k) was perhaps marginally more acid and less rich than along the west of the island (site l). This difference might, however, be related to the extent of raised beach that was surveyed. The beach at site l was recorded over 3.7 km whereas that at site k was recorded over only 250 m. There is likely to be less diversity, and more influence by local geological and drainage conditions, when a lesser extent of beach is recorded. The ditches and depressions at site k notably contained plants that are associated with oligotrophic bog pools, e.g. *Sphagnum* spp., *Eriophorum angustifolium* (Ellenberg's N = 1) and *Menyanthes trifoliata* (Ellenberg's N = 3). *Schoenus nigricans* (Ellenberg's N = 2) was also frequent at this site, although it is not included in Table 1 because it is not on the Palmer & Newbold (1983) checklist of freshwater plants. A disadvantage of recording as one site the 3.7 km of raised beach along the west of the island, that made up site l, is that local diversity was lost. The vegetation was not uniform, probably in response to local variation in pH, base richness and nutrient availability.

The flooded quarry pool on the raised beach (site m) was shown to be an outlier by DECORANA (Fig. 1). The mean Ellenberg's R and N values suggested that this site was less acid and more enriched than the other raised beach sites (mean R = 6.0 and mean N = 4.7) indeed these mean values exceeded those for all the other sites except for the outflow channel from the twentieth century reservoirs (site j). Plants recorded only at the quarry pool (site m) were *Alisma lanceolatum* and *Lemna trisulca*, plus the recently

introduced *Nymphaea alba*. The other outlying site on the raised beach, the grazed pasture (site n), was also less acid and more eutrophic than most sites; nutrient enrichment might be related to high stock levels. Few freshwater plants were found at this site, i.e. six species that were on the Palmer & Newbold (1983) checklist plus four additional *Juncus* species; *Ranunculus sceleratus* was the only taxon that was recorded solely at this site.

The range of mean Ellenberg's N values found on Great Cumbrae (3.4-4.9) indicated that some of the freshwater sites had become richer than others. In a wider context, however, all the Great Cumbrae sites remained relatively oligotrophic. This may be demonstrated by comparison with sites in the arable lowlands of Eastern England. For example, seventeen 500 m lengths of the Driffield and Pocklington canals in East Yorkshire, enriched through application of nitrogenous fertilizer to arable land in their catchments and by discharge of phosphate-rich effluent from sewage treatment works, had much higher values of mean Ellenberg's N, ranging from about 6.1 to 6.7 (Goulder, 2003).

Forty nine of the 59 freshwater plant taxa that were recorded on Great Cumbrae (Table 1) are amongst the 157 vascular plant species that were regarded by Palmer & Newbold (1983) as aquatic plants (i.e. not including stoneworts or riparian and wetland plants judged not to be fully aquatic) that occur in Scotland. This represented about 31% of the total Scottish freshwater aquatic plant flora. Comparison with plant records for the larger Clyde islands suggests that Great Cumbrae has a less rich freshwater flora than Arran or Bute. Church & Smith (2005) list 73 taxa that occur on Arran and are on the Palmer & Newbold (1983) checklist while Hannah (2007b) lists 90 taxa on Bute that also feature on the Palmer & Newbold checklist (i.e. 47% and 57% respectively of the total Scottish freshwater flora).

It appears, therefore, that the freshwater flora of Great Cumbrae is somewhat limited, although some taxa are likely to have been missed in the present study. Indeed there are 29 taxa that are on the Palmer & Newbold (1983) checklist that have been recorded on Great Cumbrae (Hannah, 2008) but were not encountered during the present study. Of these, *Potamogeton alpinus*, *Eleogiton fluitans* and *Glyceria declinata* were recorded in 1996 at upland lochan sites (JNCC Standing Waters Database – unpublished) by the then ongoing botanical survey of Scottish freshwater lochs (Lassiere, 1995; Duigan, Kovach & Palmer, 2006), and *E. fluitans* has recently been re-found on the raised beach (Hannah, 2007a). Others, however, are believed by Hannah (2008) to be probable errors or to be in need of confirmation; i.e. *Berula erecta*, *Carex acuta*, *C. vesicaria*, *Myosotis scorpioides*, *Myriophyllum spicatum*, *Oenanthe fistulosa*, *Potamogeton lucens*, *Ranunculus lingua*, *R. omiophyllus*, *R. trichophyllus*, *Utricularia minor*, *U. vulgaris* agg., *Veronica catenata* and *Zostera marina*. The relatively limited diversity of the Great Cumbrae freshwater flora is likely to be related to the limited range of freshwater habitat; especially the absence of natural lochs and the sparcity of calcareous freshwater sites. It is relevant that most of the freshwater bodies on the island are artificial and are largely nineteenth century or later in origin, hence freshwater plants have had a limited time to colonize, in contrast to terrestrial species that have had the 10 000 years or so of the post glacial period in which to establish themselves, including several thousand years of increased habitat diversity brought about by human activity (Edwards & Whittington, 2008). Some of the island's freshwater plants will, however, be longstanding, their original habitat being boggy places and the few natural watercourses on the island. Furthermore, freshwater plants tend to be good at dispersal perhaps because of the intermittent nature of many freshwater habitats (Preston & Croft, 1998), hence other colonizers of new freshwater sites will have arrived by natural dispersal mechanisms (e.g. wind and carriage by birds, externally or in their guts).

Alien freshwater plants were not much in evidence during the present study; of the 23 species of freshwater vascular plants listed by Farrell (2001) as naturalized aliens in Britain only *Elodea canadensis* was recorded (Table 1), while *Nymphaea alba*, in the flooded quarry pool (site m) was the only species that had obviously been introduced by direct human intervention. This contrasts with Arran which has the invasive New Zealand pigmyweed, *Crassula helmsii* (Church & Smith, 2005; also in a pond in the gardens of Brodick Castle in June 2009) and the intermittently-occurring but potentially invasive water fern, *Azolla filiculoides* (Church & Smith, 2005).

None of the freshwater vascular plants recorded on Great Cumbrae (Table 1) were rare, or scarce in the sense that they have been recorded in not more than one hundred 10 km x 10 km squares in Britain (Stewart, Pearman & Preston, 1994). The occurrence of *Alisma lanceolatum* and *Lemna trisulca*, both in the flooded quarry pool on the raised beach (site m) and both outside their generally southern and eastern range in Britain (Preston, Pearman & Dines, 2002) is, however, interesting and somewhat perplexing. The record of *Juncus x kern-reichgeltii* at Lower Cumbrae Reservoir was provisional and based on possession of intermediate characteristics and the presence of both parents; confirmed records of this hybrid are, however, best based on voucher specimens (Lansdown, 2008) which were not collected. Three stoneworts were recorded, *Chara virgata*, *Nitella flexilis* and *N. translucens*; of these only *C. virgata* is shown as occurring in vice-county 100 by Moore (1986) while *N. flexilis* is a nationally scarce species in the UK (Stewart, 2004). They may, however, be under-recorded; all three species are to be found in lochs on Mull and in Dumfries and Galloway (Stewart, 2004).

From the conservation perspective the entirety of the freshwater sites and their plant communities are of more value than the individual plant species. The open

water sites on the island are liable to be neglected because they have lost their water supply function and/or their agricultural/economic value. Thus many of the lochans have little or no remaining free-standing water; i.e. Wee Minnemoer (no longer used as a curling pond), the small derelict reservoir about 100 m south-east of Minnemoer (site c), Davy's Dub, and Loch Leech. Furthermore, the marginal vegetation of Minnemoer (site a) has suffered considerably over the period 2003-2009 due to extensive grazing and trampling by cattle. The two twentieth century reservoirs, although no longer used for water supply, survive presumably because of their amenity value and the considerable economic cost of demolition. The abandoned wet pastures on the raised beach in the south-east and west of the island (sites k and l) are known to be species-rich (Hannah, 2007a), have conspicuous stands of *Iris pseudacorus*, and are of aesthetic and botanical conservation value. They do not suffer from high grazing pressure, in contrast to much of the wet pasture on the east side of the island (site n), but they are potentially at risk from succession. There are areas where willow scrub is developing. There is also encroachment by invasive alien shrubs at the raised beach site adjacent to the Marine Biological Station (site k). Here *Rhododenron ponticum* is widespread and *Fallopia japonica*, which has colonized widely alongside the perimeter road (Meadows & Meadows, 2004), is extending its range across the raised beach.

Extrapolation, on the basis of the present study, would be risky but it is suggested that the principal environmental pressures that might drive change in the distribution and habitats of freshwater plants on Great Cumbrae are (1) benign neglect of sites that no longer have water-supply or agricultural/economic functions, and (2) eutrophication, possibly related to tree planting, fertilizer application, and cattle farming.

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	Lochans	Early 20th Century reservoirs	Coastal sites on raised beach
Submerged and floating-leaved plants			
Callitriche sp.	a, c, d, e, f, g	h, j	l
Chara virgata	-	i	-
Elodea canadensis	e	h, i, j	-
Lemna minor	c, e, f	-	m
L. trisulca	-	-	m
Littorella uniflora	a	h, i	l
Myriophyllum alterniflorum	a	h	-
Nitella flexilis	e	-	-
N. translucens	a	-	-
Nymphaea alba	-	-	m†
Potamogeton berchtoldii	-	h, i, j	-
P. gramineus	a	h, i	-
P. natans	a, e	h, j	m
P. polygonifolius	a, b, c, e, f	-	k, l
Emergent plants			
Agrostis stolonifera	a, b, c, d, e, f	h, i, j	l, m
Alisma lanceolatum	-	-	m
Apium inundatum	a	-	-
A. nodiflorum	-	-	l
Baldellia ranunculoides	a	-	l, m
Caltha palustris	e	i, j	k, l, m
Carex nigra	b, d, f	h, i	k, l, m
C. rostrata	a, c, f	-	-
Drosera rotundifolia	a, c	-	-
Eleocharis palustris	a, b, c, d, e	h, i	k, l, m, n
Equisetum fluviatile	a, b, e, f, g	i	k, l, m
E. palustre	-	h, j	-
Eriophorum angustifolium	a, b, c, f	-	k, l
Galium palustre	a, b, c, e, f, g	h, i	k, l, m
Glyceria fluitans	a, c, d, e	j	l, m, n
Hydrocotyle vulgaris	a, b, c, e, f	i, j	k, l, m
Iris pseudacorus	f, g	i, j	k, l, m
Juncus acutiflorus	a, b, c, e, f, g	h, i	k, l, m, n
J. articulatus	a, b, c, d, e, f	h, i, j	k, l, m, n
J. bufonius	a, b, d, e	h	l, n
*J. bulbosus**	a, b, c, d, e, f	i	l
J. conglomeratus	a	h, i, j	k, l, n
J. effusus	a, b, c, d, e, f, g	h, i, j	k, l, m, n
J. inflexus	-	i	-
J. x kern-reichgeltii	-	i	-
J. squarrosus	d	-	l
Lythrum portula	a, f	-	-
Mentha aquatica	c, e, g	h, i, j	k, l, m
Menyanthes trifoliata	a, c, f	i	k
Myosotis laxa	a, c, f	i, j	-
M. secunda	e	i, j	-
Oenanthe crocata	-	-	l
*Persicaria amphibia***	a, g	h, i, j	k, l, m
Phalaris arundinacea	-	i, j	l, m
Phragmites australis	-	-	m, n
Potentilla palustris	a, b, c, e, f, g	i	k, l
Ranunculus flammula	a, b, c, d, e, f	i, j	k, l, m, n
R. hederaceus	a, c, d, e, f	-	l
R. sceleratus	-	-	n
Rorippa nast.-aquaticum agg.	e	h, i, j	l, m
Samolus valerandi	-	-	k
Sparganium erectum	g	i, j	m
Typha latifolia	b, c	h	-
Veronica beccabunga	e	i, j	l
V. scutellata	a, b, c	-	-

Table 1. Freshwater plants recorded on Great Cumbrae, 2003-2009. The site identifiers indicate the sites at which each taxon was recorded (see text for key to site identifiers); *occasionally with submerged habit; **sometimes with natant habit; †Introduced between June 2007 and June 2008.

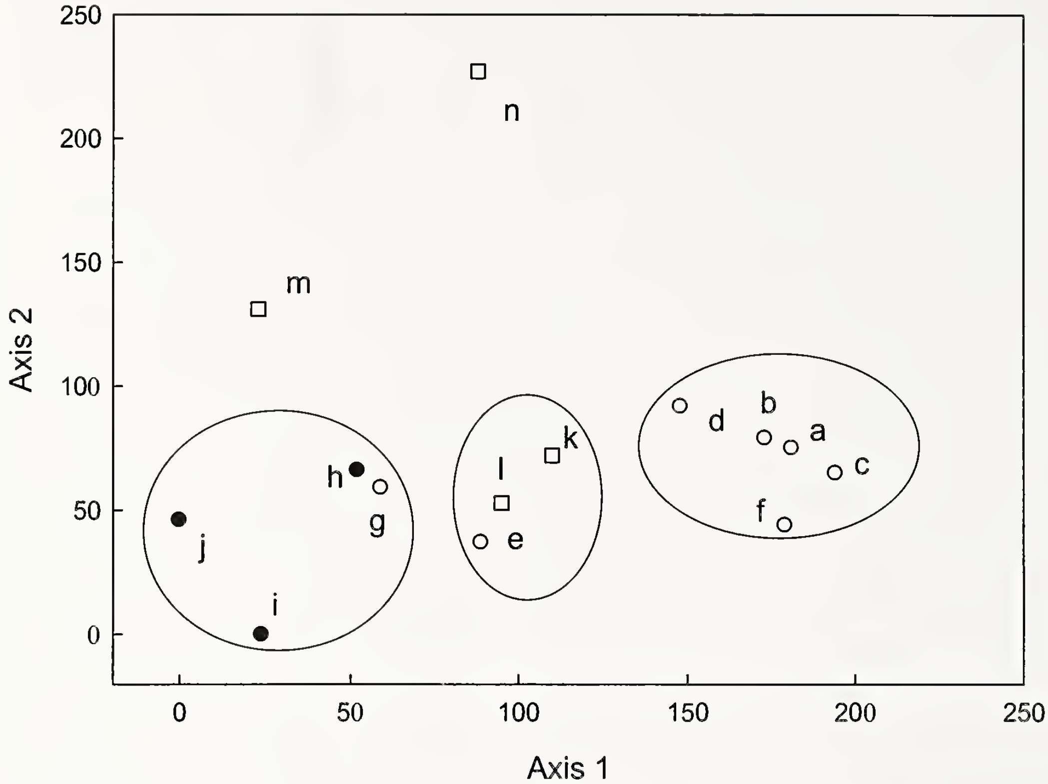

Fig. 1. DECORANA plot: open circles indicate lochans, closed circles indicate early twentieth century reservoir sites, and open squares indicate sites on the raised beach (see text for key to site identifiers).

Site	pH	Conductivity (μS cm^{-1})	Mean Ellenberg's R*	Mean Ellenberg's N*
Lochans				
(a) Minnemoer	6.2**, 6.3‡	125**, 86‡	5.1	3.4
(b) Wee Minnemoer	5.6†	111†	5.2	3.4
(c) Derelict reservoir c. 100 m SE of Minnemoer	6.0‡	58‡	5.1	3.6
(d) Small reservoir c. 300 m SE of Minnemoer	6.6‡	86‡	5.0	3.8
(e) Two small reservoirs c. 400 m NE of Minnemoer	6.7**, 6.1‡	132**, 104‡	5.7	4.3
(f) Davy's Dub	-	-	5.1	3.5
(g) Loch Leech	-	-	5.6	4.6
Early twentieth century reservoirs				
(h) Upper Cumbrae Reservoir	6.4**	264**	5.7	4.3
(i) Lower Cumbrae Reservoir	6.3**	292**	5.7	4.3
(j) Reservoir outflow channel and Mill Burn	-	-	6.0	4.9
Coastal freshwater sites on the raised beach				
(k) Abandoned wet pasture at the SE of the island	-	-	5.3	3.5
(l) Abandoned wet pasture on W side of the island	-	-	5.4	4.1
(m) Quarry pool at the SW of the island	6.2†	382†	6.0	4.7
(n) Wet pasture on E side of the island	-	-	5.6	4.4

*Number of taxa used in calculating mean values ranged from 9-30; average=20.4; **July 2003; †June 2004; ‡June 2009.

Table 2. pH, conductivity and mean Ellenberg's R and N values for Great Cumbrae freshwater sites.

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Thirty years as plant recorder for Lanarkshire (VC 77) — a pearl anniversary. The pearls and perils encountered

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INTRODUCTION

This paper is based on a presentation given to the Glasgow Natural History Society (GNHS) on 10th February 2009. The article describes some of the pearls and perils encountered during the 30 years for which I have been the Botanical Society of the British Isles (BSBI) plant recorder for Lanarkshire (VC 77). The Pearls are categorised into sites and individual plants. With regard to Perils, how is this for a start- I have seen on a poster BEWARE OF PLANTS and on others DANGER OF DEATH which doesn't always keep me out if it looks inviting. The perils experienced are reported during the course of the article.

This is not a comprehensive account about the plants in the wild in Lanarkshire, but in order to appreciate the quality of sites and species, it is helpful to know the records in the various categories. The overall total of plants ever recorded in the vice-county is 1994, of which 895 were native and 1099 alien. The total in the post-1978 era is 1750, with 844 in the native category and 906 alien.

RECORDING

Going back 30 years, my hospital base was an Institute in the grounds of the Southern General Hospital (SGH), so it seemed logical to start recording in the neighbourhood – nipping out at lunch time, often with a colleague, and beginning at the extreme western tip of the VC. I called this Lanark's Nose. That part in VC 77 is only 39% of the 1km square 26/5167, an area of only 39 hectares (96 acres). I was not expecting to find more than factories, roads and railway lines, but was pleasantly surprised by the diversity of habitat and the recording of 266 taxa, i.e. 15% of the post-1970 total. The vast majority of the 266 were native and the pearls included: variegated horsetail (*Equisetum variegatum*) which had only one previous record (Hennedy 1865 at Frankfield Loch), marsh stitchwort (*Stellaria palustris*) included in the BSBI Threatened Plants Project and musk mallow with only one Lanarkshire record in the 1962 *Atlas of the British Flora* (Perring & Walters). There were five orchid taxa. For the first few years northern marsh-orchid (*Dactylorhiza purpurella*) remained outwith the VC boundary, but one year I discovered that it had crept in and within two years there were over 1000, and it had hybridised with common spotted-orchid (*D. fuchsii*), one of those already present. Another was common twayblade (*Listera ovate*). Spotted laurel (*Aucuba japonica*), white-stemmed bramble (*Rubus cockburnianus* and French meadow-rue (*Thalictrum aquilegifolium*) were among the aliens new to the VC.

Moving 'inland' to just west of the SGH, in an abandoned industrial estate I saw an unusual grass. This proved to be the inter-generic hybrid between creeping bent (*Agrostis stolonifera*) and water bent (*Polypogon viridis*), with the scientific name X *Agropogon robinsonii*, the only previous world records (1924 & 1953) being from Guernsey—so the third world record. Some pearl! The location was 20 metres from the edge of a lorry park and 500 from a dock. While recording in this area over lunch time, wearing my white coat, a security man asked, "Are you a pathologist looking for a body?"

Beside an active line in Govan a colony of an unusual spurge was noted. When sent to the referee, I wrote that I could not identify the specimen, it seemed closest to *Euphorbia waldstenii* but his article stated that this did not occur in Britain. I got back a one-liner—"Dear Dr Macpherson, you have proved me wrong".

To the east the next Pearl was the site of the 1988 Glasgow Garden Festival in which my Grand-daughter, Emma Lindsay, and I recorded on many occasions in the early 1990s and was the subject of a BSBI Presidential Address (Macpherson 1993). Some may remember that the brochure stated that 'the Festival was part of a process which was transforming the south side of Glasgow, one million trees and shrubs formed the backdrop to a floral carpet of bedding displays and themed gardens'. When it closed, the bulldozers moved in and by 1990 practically all trace had been removed and looking at the site in 1991 when the main area had largely returned to being waste ground, one could hardly imagine that it had ever been. I did not record plants which were at the site of original planting, but noted a total of 325 comprising native by natural dispersal 71%; spread from planted material 19%; doubtful status 5% and stowaways 2%. A surprising native rarity was water chickweed (*Myosoton aquaticum*) near the quay edge. There were > 50 plants of pearly everlasting (*Anaphalis margaritacea*) scattered widely. This, of course, was a cultured

(cultivated) pearl, rather than a natural one. Stowaway pearls included orange foxtail (*Alopecurus aequalis*) and smooth rupturewort (*Herniaria glabra*), both with only two other post 1970 Scottish casual records and Leatherleaf sedge (*Carex buchananii*), new to Britain as a wild plant. Clive Stace borrowed my specimen in order to describe the species in his updated 1997 *New Flora of the British Isles*. As a result of the recording in such an area I considered that there were too many vague terms relating to plant status and initiated a BSBI sub-committee which produced definitions in the different categories of Plant Status Nomenclature. After all, the requirement for a clear knowledge of status without ambiguity is clearly indicated by the story of the young man from the west of Scotland who went into a London establishment that he would not have patronised had he known its reputation. He chatted to a young lady for some time and eventually she leaned forward, touched his arm and said, "You do realise that I am a Coll Girl?" He leant back- "Now, is that not a coincidence- I'm from Tiree".

Abandoned industrial sites have proved of interest. A foundry site with alkaline soil at New Stevenston has blue fleabane (*Erigeron acer*), but what I missed at two visits was the special native pearl, yellow bird's-nest (*Monotropa hypopitys*) (Plate 1) Near Celtic Park, it is the adjacent waste ground that, to me, is "Paradise". Mind you in such sites one's eyes can light up for a few moments, before realising that what one is seeing is "*Flora Plastica*" (Plate 1). Flaky Juniper (*Juniperus squamata*) is new to Britain as a plant in the wild, but a hidden danger. A prostrate shrub approximately 10 yards in diameter was seen in an abandoned industrial site. I could not decide from the map into which 1km square the juniper should be recorded. Accordingly, I switched on my GPS and strode in towards the centre of the plant. I had taken four paces in when my right lower limb went full length down a hole! Fortunately the plant was over one foot thick by then and springy, so that no trauma was sustained. I have been informed that it has sometimes been used as a man-hole cover!

Sometimes one has to take steps to gain access to sites- literally. We climbed up our ladder, carefully, onto an abandoned railway viaduct and lines at Dalmarnock and found growing juneberry *Amelanchier lamarckii*, - no other established Scottish sites and *Cotoneaster astrophoros* which was the first British record. Lanarkshire has four cotoneasters which were first British records, including a large bushy shrub *C. hylmo*, actually det. for me by Hylmo, a Swedish botanist after whom the plant is named; and an additional 16 which are new for Scotland. Recently I received a letter from the BSBI alien specialist in which he wrote that to have 36 cotoneaster taxa in one VC must be a world record! In the sidings at Cadder, Jim Dickson & Dick Hunter found *Alchemilla acutiloba*, the only other British record being from Co Durham.

During his GNHS Presidency, Geoff Hancock initiated a survey of the Natural History of the Botanic Gardens. This included the recording of plants growing in a wild state. In this category a total of 279 taxa was recorded (native 58%). The pearls were the accidental introductions (stowaways) *Gilia inconspicua* and *Linaria amythystea* ssp. *multipunctata* new to Britain. Neither have names in English- *multipunctata*—I christened the latter 'Pluke-faced Toadflax'. While recording on one occasion, I went back to the car and told my wife that I wouldn't be long, I was just going to nip down to the river bank to photograph a couple of naked ladies. Her knowledge of *Colchicum autumnale* was such that she just nodded. More recently stinking goosefoot (*Chenopodium vulvaria*) has been noted in a cereal bed, with only one post-1970 Scottish record.

For many years I have known small-leaved blinks (*Montia parvifolia*) to be established on rocks on the bank of the White Cart Water near Meikle Dripps, Busby. Its only British record. A lady who did drawings of alien plants asked to be taken to the site.

Early in 2008, on the muddy bend of a burn, SE of Croftfoot, I saw a colony of a plant with circular leaves 2-3ft in diameter on stalks 3-4ft tall and later 9ft tall. From the base came flower stalks. I could not find a match in either wild flower or gardening books. It was obviously a new record for Lanarkshire—an alien pearl! While checking the grid reference on the A-Z Map, I noticed that there was a nursery further up stream and surmised that it might have escaped therefrom. Accordingly, for a fortnight I had it in mind to take up a specimen to see if I could have it identified. On the morning that I decided to go, I had a thought, and because of that, did not actually take the specimen when I went to the nursery, which <u>was</u> for children! I have since learned that it is the female form of butterbur (*Petasites hybridus*), a plant of north and central England and exceedingly rare elsewhere—so <u>a native</u> lady pearl.

Now moving to more natural habitats:
It was a favourite saying of Professor Hooker that every West of Scotland naturalist had received his baptism in Possil Marsh. A little pearl in that part of Glasgow. Of special botanical interest are greater spearwort (*Ranunculus lingua*) and tufted loosestrife (*Lysimachia thyrsiflora*) included in a composite plate produced for us by Norman Tait for *The Changing Flora of Glasgow* (Dickson *et al* 2000). In the adjacent canal there is arrowhead (*Sagittaria sagittifolia*), a pearl recently discovered by Keith Watson and seen by those of us who attended the Field Meeting at the Glasgow Bridge last July. In the neighbourhood one finds the hybrid pondweed *Potamogeton* x *benettii*, known in <u>the world</u> only from the Forth and & Clyde Canal and a few adjoining water bodies. In a cut-off meander of the River Kelvin I found that New Zealand pigmyweed (*Crassula helmsii*) had invaded Lanarkshire. Despite its small size, it can obliterate other plants and is therefore perilous to native plantlife! In the Glasgow to Bothwell section John Lyth recorded mudwort (*Limosella aquatica*) from the bank of the River Clyde near Cambuslang in 1986, a new record.

Plate 1

a

d

e

b

c

f

a Young's helleborine

b Pink stonecrop

c Cloudberry

b *Persicaria runcinata*

c *Flora Plastica*

f Yellow bird's nest

At Bothwell, Jim Dickson noted that the St. John's-wort hybrid was not the usual one between the common ssp. of imperforate and perforate, but -a real pearl. It is the cross involving ssp. *maculatum* and called nothossp. *carinthiacum*. There is an old record from Skipness, but the Bothwell occurrences are now the only ones known in Britain. At Low Blantyre, Keith Watson found a strong colony of grey sedge (*Carex divulsa* ssp. *leersii*) on the bank of the River Clyde. There are only three previous Scottish records and this the first in the west. This plant is a strong calcicole, we did pH analysis and found the soil to be neutral. Nearby on bings we have an orchid, originally classified as Young's helleborine (*Epipactis youngiana*) which was new for Scotland – though by isozyme tests etc, doubt has been cast on its validity, and the taxon is now regarded as *E. helleborine* var. *youngiana* (Plate 1). To me, as an amateur field botanist, it looks distinct! Dune helleborine (E. dunensis), for which there are only two other Scottish records, also grows in the neighbourhood. Bings are also sites for moonwort (*Botrychium lunaria*), common wintergreen (*Pyrola minor*), viviparous fescue (*Festuca vivipara*) and alpine (*Diphasiastrum alpinum*), fir (*Huperzia selago*) and stag's-horn (*Lycopodium clavatum*) clubmosses, but the pearl in this group is the alpine, interrupted clubmoss (*L. annotinum*), considered to be extinct in southern Scotland until recorded by Keith Watson from the bing north of Shotts.

On into the Clyde Valley, where there are notices warning visitors of the dangers! Along the tributaries we have herb-paris (*Paris quadrifolia*), yellow Star-of-Bethlehem (*Gagea lutea*), bird's-nest orchid (*Neottia nidus-avis*), toothwort (*Lathraea squamaria*) and wood barley (*Hordelymus europaeus*) in its only extant Scottish site. Visitors who have been impressed by the Falls of Clyde include Wordsworth who composed a short poem, his sister, Dorothy who expressed delight, Bishop Pococke, Coleridge, Pennant, Sir Walter Scott and paintings were done by Jacob More and JMW Turner. Nowadays the falls at Corra Linn are seen in their full glory only when the river is in spate and the water to the power station is turned off. I find it strange that a linn can refer either to a water-fall or to the flat water at the base of a water-fall. Linne is Gaelic for a pool; hlynn is Old English for a torrent. I prefer to think of a linn as the former.

One of the pearls of the Clyde Valley is Purple Saxifrage (*Saxifraga oppositifolia*) growing on the rocks at Corra Linn. To gain access, one has to negotiate steep, fragile, very slippery ancient stone steps. Some years ago I led a combined field meeting to the area and took along our grandchildrens'water-ski tow-rope. This was attached to the fence at the top and gave something to hold on to going up and down. I did not want there to be any human falls at the Falls of Clyde. In this area Meadow Saxifrage (*Saxifraga granulata*) is a rock plant! Other rarities include Star-of-Bethlehem (*Ornithogalum umbellatum*), lily-of-the-valley (*Convallaria majalis*), Scottish laburnum (*Laburnum alpinum*), early-purple orchid (*Orchis mascula*) and Wood Vetch (*Vicia sylvatica*).

A few years ago a Scottish Wildlife Trust warden noted near Corra Castle, that a colony of a rather insignificant grass, which many botanists (including me) over the years had just regarded as a poor specimen of hairy-brome (*Bromus ramosus*), was actually lesser hairy-brome (*Bromus benekenii*), a national rarity.

Just above Bonnington weir there is a colony of a water-buttercup, out of reach from the bank. Attempts to get a specimen with the grapnel were futile; bits just broke off and drifted down over the dam. I went back to the car, got my waist high waders, tied the grapnel end of the rope to a tree, the other round my waist and—well not quite threw myself in. Paid out the rope gently & gingerly and obtained a new record for the vice-county. In the same vein, one day I was recording along the river near Hazelbank where it is shallower, but much faster, with my grand-daughter (Emma). Before the botanising I had bought her a new pair of yachting boots for her birthday. We saw another water-crowfoot, so Emma went back to the car, christened the boots in the River Clyde, and just managed to obtain a specimen with the aid of her Grandmother's walking stick. This also proved to be a new VC record—pearls somewhat perilously obtained.

On the river bank at Hazelbank there is a eultured pearl—*Persicaria runcinata*; an established colony, new to Britain in the wild and presumably either fly-tipped or deposited when the river was in spate (Plate 1).

Actually, the first experience of a peril was back in 1996 when our grandchildren were with us on a GNHS Evening Field Meeting to Kittoch Glen. There was an unexpected excitement. Approximately 30 young cattle came charging down a wooded hillside straight for us. Instinctively, the adults formed a cordon round the children and for the first time I swung my vasculum at the approaching herd. They stopped about six yards away and backed off. Subsequently I have used the vasculum as a method of defence against cattle on about five occasions, once hitting a beast on the nose twice before it turned away. A couple of years ago, when about to cross a field with young beasts up in the Clyde Valley, a farmer gave me a piece of plastic tubing and told me to wave it behind me. I was sceptical, but it worked. The vasculum has also been used as a defensive weapon against dogs on three occasions, and once while recording along a river, a swan, which I suddenly noticed was making straight for me, and only 4 feet away. Ornithologists will be pleased to know that I did not bash the bird, just pushing out the vasculum in jerks and the swan took evasive action. Looking round, there was a nest with eggs six feet further along the bank.

Once when recording on the south side of Glenbuck Loch, a man I met said, "You're all right this side, but

beware if you go round to the north- he comes out with a shotgun". There are other dangers when recording, - if one is superstitious. The white eye of a speedwell was called the Eye of Christ in some parts of the country and the Devil's Eye in others. In either case, it was believed that one trampled or otherwise damaged it at one's peril. As punishment, avenging birds might set upon your mother. In some areas speedwells were actually called "Pick-your-mother's-eyes-out "and in others, even "Tear-your-mother's-eyes-out"- so beware!

In 2004 I was informed by John Howell that a plant, tentatively identified as dyer's greenweed (*Genista tinctoria*) was growing on the embankment of the M74 NW of Abington. We went down to the area, stopped on the hard shoulder, and while one walked slowly round the car looking at the tyres, the other went up the bank, obtained a specimen, diagnosis correct, a photograph and a GPS reading. After all, if one breaks down on a motorway, one is supposed to go up the bank as it is perilous to stay in the vehicle.

Some years ago I went with my daughter, Elspeth Lindsay to record on Gana Hill, down adjacent to the border with Dumfries. On the journey south I happened to mention that I had never seen lesser twayblade (*Listera cordata*) in Lanarkshire. Gana Hill is a site for real pearls. In 1997 Keith Watson had recorded alpine meadow-rue (*Thalictrum alpinum*) and alpine saw-wort (*Saussurea alpina*), and while we were up top in 1998 Elspeth drew my attention to Alpine Bistort (*Polygonum viviparum*)—all new vice-county records. Coming back down the hill, Elspeth tripped, fell flat and lay still. I shouted across, "Are you all right?" "Yes, but I'm not moving till you come and see what's under my nose";—yes lesser twayblade, a peril leading to a pearl.

Marsh valerian (*Valeriana dioica*) was reported by Keith Watson and Henry Noltie from the side of the Glenthirston Burn up from the M74, just before the county boundary. I like to see all the plants recorded in Lanarkshire (especially national rarities- pearls), and despite obtaining site instructions failed, but went back with Elspeth who located the little colony.

Similarly, two visits were necessary for me to see the alpine, chickweed willow-herb (*Epilobium alsinifolium*). The recorder for Peebles-shire (David McCosh) had strayed into south Lanarkshire and reported having seen it in high up by the Mirk Grain burn, near Hare Cleuch Head. This is indeed a pearl and he offered to take me to the site. This involved going further down the M74 out of Lanarkshire and doubling back on the A701 Moffat- Edinburgh road. Then a steep climb up through a forest, back into VC 77 and a half mile trek across moorland to the top of a gulley. He is 6ft 2" tall and with his long legs and heather stride was soon a few hundred yards ahead. It would have been dangerous for me to try to keep up, perhaps tripping, perhaps collapsing, so I just took my time. He did stop near the head of the gulley into which we were going. My course took me about 20 yards higher up the slope and when I was about 20 yards away I called out, "Cloudberry up here", to which I received an exasperated comment, "That's what I've been waiting 10 minutes to show you" (Plate 1). We could not re-find the willow-herb, but as a consolation I saw a very attractive clump of pink (hairy) stonecrop (*Sedum villosum*), my favourite plant. I went back the following year with John Hawell, we took our time and did locate the pearl (Plate 1).

Down in the Leadhills there is a pearl site- a bank with wall whitlowgrass (*Draba muralis*), frog orchid (*Coeloglossum viride*), field gentian (*Gentianella campestris*) and masses of proliferating dwarf water avens (*Geum rivale*)- perhaps lead poisoning? Just at the end of the bank there is a notice stating, "Beware Flash Floods".

The Culter Valley is home to starry saxifrage (*Saxifraga stellaris*), burnet rose (*Rosa pimpinellifolia*) and juniper (*Juniperus communis*). A damp rock face by Camps Reservoir has a strong colony of *Primula juliae*), the first British record. Crawick Moss has the pearls white beak-sedge (*Rhynchospora alba*), few-flowered sedge (*C. pauciflora*) and tall bog-sedge (*C. magellanica*). Botanists from England have come to see the latter.

Land owners, farmers, security officers etc never fail to be impressed with what I call my Access Card – yet it has no standing whatsoever. I designed and had it printed myself. It always gets me in, but it cannot get me out when I am padlocked or otherwise blocked in! A peril of recording.

On one occasion, just east of 'Lanark's Nose', I returned to the car on a late Friday afternoon to discover large concrete blocks across the exit—in preparation for a development. I raced the car to the other end of the road where the gates into the King George V Dock were always padlocked. Very fortunately, within two minutes the security officer was passing on his way home and I managed to attract his attention. I arranged to leave the car in a nursery one morning, both for safety and to get it off the road. I returned to collect it at 12.40—closed for lunch! One Sunday afternoon I drove into the grounds of Daldowie Crematorium in order to record along that part of the River Clyde. When I tried to get out at 4.30, I discovered that the gates were padlocked. Having driven back to the crematorium and round the grounds I realised that there was no caretaker on site and went back up to the gates. After a few minutes thought, I took the car back 50 yards and raced up the bank, over the flower bed wheels spinning, down the other side onto the road and didn't look back! In the past few years there has been an addition to my botanical equipment, now I carry also a hacksaw.

One Saturday afternoon, I was returning down a farm track in southern upland Lanarkshire when I found a tractor obstruction. There was no reply at the house,

but fortunately I was able to drive in the one gateway and out the other. A notice "Deep Excavation" was really an abandoned reservoir, so that did not keep me out and "Thin Ice" isn't going to bother me. However, roses and brambles can tear clothes and prick fingers. I have never felt threatened while recording alone. Over the years > 30 individuals met have asked to accompany me. Age range 7-70, mostly 12-14. D'ye need this yin mister? The Family contribute in different ways and are very supportive; recording, illustrating, computer help, improving the English, etc. I even had a birthday cake baked in the shape of Lanarkshire (vice-county 77).In the past 30 years, 685 new records have been made (176 of them native); 33 taxa have been recorded in Lanarkshire which are new for Britain and 49 which are new for Scotland.

It has been said that a Botanist travelling from the south of England to the north of Scotland would probably find that part from Lockerbie to Glasgow the most uninteresting of the entire journey (Birnage 1975). However, in addition to **perils,** Lanarkshire has its **botanical pearls** if one knows where to look.

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New records of scaleworms and their allies (Polychaeta: Aphroditoidea and Pisionoidea), from the Clyde and Argyll Sea Area, with notes on parasitic copepods, commensal entoprocts, and other epizoans

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ABSTRACT

New records are provided of 31 species of scaleworm (and allied taxa) collected over a period of years from the Clyde and Argyll Sea Area. The species *Pisione remota, Enipo elizabethae, Harmothoe antilopes, H. pagenstecheri, H. spinifera, Malmgrenia castanea, Malmgrenia ljungmani* and *M. marphysae* are newly recorded from the area, while *Harmothoe fragilis* is found for the first time from Scottish waters. The widespread occurrence of both *Pholoe inornata* and *P. baltica* in the area is confirmed. New records are also provided of parasitic copepods associated with scaleworms including *Selioides bocqueti, Herpyllobius polynoes, Herpyllobius arcticus*, and *Eurysilenium truncatum. E. truncatum* is confirmed for the first time from British waters. Additional records are cited for entoprocts, hydroids, bryozoans and stalked ciliates attached to specimens of *Gattyana cirrhosa* or *Aphrodita aculeata.* The entoproct *Loxosomella glandulifera* is recorded for the first time from British waters.

INTRODUCTION

The scaleworm families (Polynoidae, Acoetidae, Pholoidae, & Sigalionidae) and their allies the prongworms (Pisionidae) and the sea mice (Aphroditidae) are among the most readily recognisable of polychaete worms and are common in both intertidal and sublittoral habitats. They frequently occur in benthic macrofaunal monitoring surveys although many of these records remain hidden in unpublished environmental impact reports. The aim of this communication is to bring to light the records held by SEPA (South West Area) in line with the current interest in documenting marine biodiversity.

The records included here originate mostly from monitoring surveys carried out since 1990, undertaken by the authors under the then Clyde River Purification Board (CRPB) and since 1996 under the Scottish Environment Protection Agency (SEPA). Although numerous CRPB records prior to 1990 exist they are not cited except in a few cases where voucher specimens have been retained and identities verified by the present authors. All records between 1990 and 2007 are included plus a handful of later records for rarer species.

Unless otherwise stated, the surveys generally involved grabbing or coring of sublittoral seabed sediments, usually in association with monitoring industrial or sewage treatment works discharges or fish farm sites. Hence species from sublittoral substrates predominate while those from intertidal areas or rocky or stony habitats are poorly represented. However three infrequently recorded species were recovered from bundles of nylon mesh ("clam spat bags") moored subtidally for several months to assess settlement of scallop spat. The records for each species are arranged geographically, approximately north to south. For relatively common species only the general survey locations are given but more information on sampling stations are provided for less common species, with records from five or fewer survey occasions. For the latter, notes on the numbers per station are given and station details are shown in the appendix.

Specific identification of scaleworms generally requires microscopical examination and can be difficult especially with juvenile specimens or material fixed with formalin which is often damaged or incomplete. There have been numerous changes of nomenclature and taxonomy over the years, which make assessment of older records difficult. The works of Tebble & Chambers (1982) and Chambers (1985) on Scottish scaleworms, and the subsequent synopsis by Chambers & Muir (1997) on British scaleworms have added greatly to the knowledge of this group in UK waters. It is clear that the known distribution of scaleworms in British waters is still incomplete, especially in relation to some of the more recently recognised species. At least one species new to the British Isles has been found relatively recently in Northern Ireland (Chambers, 1989) and it is possible that this, or perhaps other new species, may yet be found in Scottish seas.

Useful notes on some of the species which occur in British waters, including reviews of the genus *Harmothoe* and *Malmgreniella* (*sic*), are provided in recent revisions of Mediterranean scaleworms by Barnich & Fiege (2000, 2001, 2003) and also the monograph on Arctic Polychaeta by Jirkov (2001). Pettibone (1993) introduced some differences in generic nomenclature such as using *Malmgreniella* for *Malmgrenia*. However the usage of *Malmgrenia* (for North Atlantic species) has recently been conserved by the International Commission on Zoological Nomenclature (ICZN, 2009). The nomenclature used here follows Chambers & Muir (1997) except for the genus *Pholoe* which was revised by Petersen (1998).

The polychaete records from the Clyde Sea Area were compiled by Clark (1960) as part of the Clyde Sea Fauna series and included notes on 28 scaleworm species and 3 allied aphroditid species from throughout the Firth of Clyde. Additional polychaete records for the Clyde and Argyll area can be found in McIntyre (1961), Clark & Dawson (1963), Pearson (1970, 1975), Gage (1972a,b) and Comely (1973). Many of these records were reviewed and amended by Tebble & Chambers (1982) and Chambers (1985).

The Clyde and Argyll marine census area, as depicted in Lincoln (1979), is larger than that of the Clyde Sea Fauna series incorporating the Firth of Clyde, including Loch Ryan, the western Kintyre peninsula, the Inner Hebrides, Loch Linnhe, and also part of the coast of Northern Ireland. This note includes records of 31 species of scaleworm (or allied taxa) including eight new to the area and one new to Scottish waters.

While scaleworms are well known as associates of other invertebrates (Pettibone, 1993) they also act as hosts to a range of parasitic copepod species, as well as harbouring other epizoans including entoprocts, bryozoans, hydroids and ciliates. New records of copepods and other epizoans associated with scaleworms and also with aphrotidid "sea mice" are provided. The epizoan species were identified with the aid of Hayward (1985), Hayward & Ryland (1990), Nielsen (1964, 1989), and Schuchert (2008).

Scaleworms and their allies (Pisionoidea and Aphroditoidea), from the Clyde and Argyll Sea Area

Family Pisionidae

Pisione remota (Southern, 1914)
Ayr Bay - Jul.94, 1 specimen at Stn.3, Girvan: Grangestone - Feb.92, 2 small grabs at each of Stns. 1, 2, 3, 5, 6, 7 (with 60, 8, 1, 2, 13, 4 specimens), Apr.92, 3 sediment cores at each of Stns. A2,B2,C2 (with 4,1,3 specimens), Campbeltown Loch - Jan.01, 8 at Stn. 10, 5 at Stn. 11, Nov.04, 1 at Stn. 10.

The prongworm, *P. remota*, is readily recognisable by its prominent antennae which resemble the prongs of a hay-fork. It is known from shallow sublittoral sandy sediments around the British Isles including the southern North Sea, the English Channel, the Irish Sea, and off the south and west coasts of Ireland. There does not appear to be any previous records from the Clyde Sea Area or from Scottish waters.

Family Aphroditidae

Aphrodita aculeata Linnaeus, 1758 (Sea Mouse)
Loch Eil - Aug.01, Lynn of Lorne: Sound of Shuna, Jun.92, Loch Creran: South Shian - Aug.01, Barcaldine Aug.01, Mull: Tobermory Bay -Aug.01, Scallastle Bay - Jun.94, Inner Firth of Clyde: Gareloch - Apr.09, Greenock, Ironotter Point - May 89, Apr.92, May 95, May 98, Cloch Point - Apr.93, Mar.96, Apr.99, May 2000, Mar.02, Apr.03, Apr.04, Apr.05, Oct.07, Rothesay - Jun.01, North of Cumbrae - Apr.93, Irvine Bay - Sep.89, Oct.92, Oct.99, Oct.03, Kilbrannan Sound - Nov.04, Gigha: Druimyeon Bay - Oct.93, Campbeltown Loch - Jan.01, Nov.04, Loch Ryan - Oct.91, Sep.92, Oct.94, Nov.96.

Aphrodita aculeata is known as the "sea mouse" and is unmistakeable with beautiful iridescent hairs along its flanks. The adults can attain lengths of 15cm or more. Immature specimens also have a distinctive brush-like appearance and most of the records above refer to juvenile specimens, only a few millimetres in length, recovered from grab samples. *A. aculeata* is widely distributed around the Scottish coasts.

Family Polynoidae

Adyte pellucida (Ehlers, 1864)
Inner Firth of Clyde: Greenock, Ironotter Point - May 95, 2 at Stn. H750, Cloch Point - May 99, 1 at Stn. CMT7, May 2000, 1 at Stn. CMT7, Cumbrae: Ballochmartin Bay - Nov.90, several on "clam spat bags", Irvine Bay - Sep.89, 1 at Stn. P.

The cusped neurochaetae help distinguish this species (along with its sibling *A. assimilis*). Both species were recorded in the Clyde Sea Fauna although Tebble & Chambers (1982) were unable to confirm this. Some of the *A. pellucida* material from Ballochmartin Bay has since been confirmed by Susan Chambers. Elsewhere in Scotland *A. pellucida* has been found in the Shetlands, the Outer Hebrides, and Loch Eil.

Alentia gelatinosa (M.Sars, 1835)
Loch Creran: South Shian - Aug.01, 1 at Stn. 5, Cumbrae: Ballochmartin Bay - Nov.90, several on "clam spat bags", Irvine Bay - Sep.89, 1 at Stn. P.

The prominent flap over the posterior part of the prostomium is diagnostic for this species. Although SEPA records are few, Tebble & Chambers (1982) describe it as common in Scottish waters.

Antinoella finmarchica (Malmgren, 1867)
Inner Firth of Clyde, Cloch Point - Apr.04, 1 at Stn. CMT7.

The single specimen comprises an anterior fragment 4mm long (for 10 setigers) retaining only one anterior

scale. This specimen was referred to *A. finmarchica* (Syn. *A. sarsi*) by S. Chambers although some confusion remains about the status of this species. In Scottish waters it is known only from Loch Etive and the Firth of Lorne.

Enipo elisabethae McIntosh, 1900
Irvine Bay - Sep.89, 1 at Stn. C (confirmed by S. Chambers), 1 at Stn. R2, Aug.95, 1 at Stn. I.
These are the first confirmed records from the Clyde Sea Area.

Enipo kinbergi Malmgren, 1865
Greenock: Ironotter Point - May 89, 1 at Stn. B2, 1 at Stn. F1, Firth of Clyde - Jun.07 - 1 at East of Toward Point (UIFM2), Irvine Bay - Sep.79, 1 at Stn. H (deposited Nat. Mus. Scot. 1995), Apr.05, 1 at Stn. H, Rothesay – Jun.09, 1 at Creamery Stn. 100ms.

These two *Enipo* species are very similar with only the occurrence of some bidentate neurochaetae in anterior setigers separating them. In *E. elisabethae* the neuropodia of first 20 or so parapodia each have about a dozen strongly bifid chaetae and just a few chaetae with finely pointed tips. In *E. kinbergi* all the neurochaetae have finely pointed tips. The chaetae tips are often covered with detritus or broken making specific confirmation difficult. However, prior to Tebble & Chambers (1982), the standard text used to identify British scaleworm polychaetes (Fauvel, 1923) did not recognise *E. elisabethae* as a separate species and consequently its occurrence has probably been overlooked. Previous confirmed records for *E. elisabethae* are only from St. Andrews (the type locality) and Loch Glencoul, North West Scotland (see McIntyre, 1961). *E. kinbergi* was confirmed from the Clyde Sea Area by Tebble & Chambers (1982).

Gattyana cirrhosa (Pallas, 1766)
Loch Eil - Aug.01, North Loch Linnhe - May 02, Lynn of Lorne: Sound of Shuna - Jun.92, Loch Creran: Barcaldine - Jun.97, South Shian - Aug.01, Mull: Fishnish Bay - Jun.90, Scallastle Bay - Jun.94, Tobermory Bay - Aug.01, Loch Sween - Jun.90, Loch Craignish - Jun.90, Loch Fyne: Meall Mhor - Aug.93, Greenock: Ironotter Point - Apr.92, May 95, May 98, Gareloch - Oct.98, Holy Loch - Apr.92, Cloch Point - Aug.93, Mar.96, Apr.99, May 2000, Apr.04, May 06, Jun.07, North of Cumbrae - Aug.93, Mar.02, Rothesay - Jun.01, Irvine Bay - Sep.89, Oct.92, Aug.95, Apr.99, Oct.99, May 2000, Apr.01, Oct.03, Jun.06, Ayr Bay - Sep.89, Girvan - Aug. 2000, Campbeltown Loch - Jan.01, Nov.04, Loch Ryan - Oct.94, Aug.97, Aug.04.

G. cirrhosa is widely distributed in Scottish waters. Although described by Clark (1960) as "not common" in the Clyde Sea Area, SEPA surveys suggest this is one of the commonest species of sublittoral scaleworms. Clark's (1960) referral to second "*Gattyana sp.*" in Clyde waters has never been substantiated and is likely to be erroneous. The scale colouration of *G. cirrhosa* with the central dark spot (see front cover of Tebble & Chambers, 1982) is quite typical. The presence of quadrefid or quinquefid tubercles on the elytra can lead to some initial confusion with *Harmothoe antilopes*. Juvenile *Harmothoe impar* which have only a few weakly bidentate neurochaetae may also be confused with *G. cirrhosa* (which has unidentate neurochaetae only). *G. cirrhosa* appears to harbour more than its fair share of parasites and commensal epizoans (see below).

Harmothoe antilopes McIntosh, 1876
Cloch Point - Apr.05, Feb.07, Irvine Bay - Sep. 89, Ayr Bay - Sep. 81 (conf. S.Chambers), Garroch Head - Nov. 2000, Kilbrannan Sound - Nov.04.

The prostomial peaks are poorly developed and may be difficult to discern. However the floret tubercles on the scales help distinguish this species. Although the tubercles on *G. cirrhosa* are quite similar, it has well developed prostomial peaks, only unidentate neurochaetae, and both stout and capillary notochaetae. In Scottish waters *H. antilopes* is known from the Outer Hebrides and the Moray Firth. There are no previous records from the Clyde Sea Area although it does occur nearby in the Irish Sea.

Harmothoe extenuata (Grube, 1840)
Cloch Point - Mar.96, 1 at Stn.CMT7 (conf. S.Chambers), Port Glasgow - Jun.01, 3 at Stn. 18 miles.

This species is widely distributed on Scottish shores. The key in Tebble & Chambers (1982) highlighted the lack of scales on posterior segments. However the posterior portions of scaleworms fixed in formaldehyde are often broken off. The key in Chambers & Muir (1997) focuses on features of the scales themselves but *H. extenuata* may still be confused with *H. impar*. For these reasons *H. extenuata* has probably been under-recorded in SEPA surveys.

Harmothoe fragilis Moore, 1910
Loch Ryan - Jul.08, 1 at Stn. WQ7.

The single specimen which had retained only a single scale with macrotubercles was determined by S. Chambers. In European waters *H. fragilis* is previously known only from the Skagerrak and off the Isle of Man. The specimen above is the first from Scottish waters. However, as this species is easily confused with *H. impar*, it may have previously been overlooked and is probably more widespread than the few records suggest. Some question remains over the validity of this taxon in European waters as few specimens have been examined. A more detailed re-description is required to help properly distinguish it from *H. impar* (S. Chambers *pers.comm.* 2008).

Harmothoe imbricata (Linnaeus, 1767)
Loch Creran: South Shian - Aug.01, Loch Fyne: Meal Mhor - 1989 on oysters, Rothesay - Jun.01, Irvine Bay - Sep.81, Oct.87, (conf. S.Chambers), Jun.06, Campbeltown – Nov.04, Aug.94, Loch Ryan - Oct.91, Oct.94, Nov.96, Sep.99.

One of the commonest scaleworms on Scottish shores. Chambers & Muir (1997) do not illustrate the macrotubercles which may occur in this species. The specimens from Loch Fyne have rows of cylindrical macrotubercles along the edge of their scales (Fig.1), similar to those depicted by Jirkov (2001, p.156). Barnich & Fiege (2000) also show macrotubercles on *H. imbricata* but with pointed (not rounded) tips.

Harmothoe impar (Johnston, 1839)
Loch Creran: Barcaldine - Jul.99, South Shian - Aug.01(conf. S.Chambers), Mull: Tobermory Bay - Aug.01, Sound of Jura – May 06, Jun.07, Greenock: Ironotter Point - May 89, Apr.92, May 95, Gareloch - Oct.98(conf. S.Chambers), Cloch Point - Apr.93, Mar.96, May 2000, Apr.04, Irvine Bay - Sep.81 (conf. S.Chambers), Sep.89, Oct.90, Oct.92, Aug.94, Aug.95, Oct.98, Oct.03, Nov.04 (conf. S.Chambers), Jun.06 Ayr Bay - Sep.89, Kilbrannan Sound – Nov.04, Girvan - Aug.98, Aug. 2000, Oct.02, Campbeltown Loch - Jan.01, Nov.04 (conf. S.Chambers), Loch Ryan - Aug.04.

Although *H. impar* is common on Scottish shores and is already known from the Clyde Sea Area, it is easily confused with other scaleworms. Juveniles can be confused with *G. cirrhosa,* while mature specimens can be also confused with *H. extenuata* or *H. fragilis* which have similar macrotubercles on the scales. It is possible that some of the records above may actually refer to these latter species. Barnich & Fiege (2000) suggested that grouping of the microtubercles on mounds on the scales of *H. impar* may help distinguish it from other *Harmothoe* species where the microtubercles are individually isolated. However grouping of the microtubercles does not appear to be obvious in Scottish *H. impar* material.

Harmothoe pagenstecheri Michaelsen, 1896
Cumbrae: Ballochmartin Bay - Nov.90.

Around a dozen large specimens (2-3cm long) were collected from "clam spat bags". *H. pagenstecheri* is unmistakeable with the enlarged ornate macrotubercles on the scales (Figs. 2, 3). It was previously considered a variety of *H. impar* until Chambers & Muir (1997) recognised its status as a distinct species. Hence some old published records of *H. impar* may include *H. pagenstecheri*. It has not been recovered in routine grab sampling and thus does not seem to be common in the Clyde Sea Area. However it may perhaps be more prevalent on hard substrates which have been rarely sampled for this study.

Harmothoe spinifera (Ehlers, 1864)
Loch Ryan – Aug.97, 3 at Stn. 7.
Irvine Bay - Jun.06, 1 at Stn. 5.

The material from Loch Ryan was not retained and the identity was not confirmed. The single specimen from Irvine Bay comprised an anterior portion with two scales (now detached) and was confirmed by S. Chambers. In Scottish waters *H. spinifera* is known only from Shetland. Clark's (1960) record from the Clyde Sea Area was referred to *Harmothoe (Malmgrenia) furcosetosa* by Tebble & Chambers (1982). The new record here indicates that *H. spinifera* does indeed occur in the Clyde Sea Area but it does not appear to be common.

Lepidonotus squamatus (Linnaeus, 1758)
Loch Creran: South Shian - Aug.01, Port Glasgow - Apr.93, Greenock: Ironotter Point - Apr.92, May 95, Cloch Point - May 2000, Apr.04, Rothesay Jun.01, Irvine Bay - Sep.89, Aug.95, Loch Ryan - Sep.90, Oct.91, Sep.92, Oct.93, Oct.94, Nov.95, Nov.96, Aug.97, Aug. 2000.

A common species in Scottish coastal waters. The number and form of the scales make this one of the easiest of scaleworms to identify.

Malmgrenia andreapolis McIntosh, 1874
North Loch Linnhe - May 02, Irvine Bay - Sep.81, Sep.89, Aug.95, Apr.99, Apr.01, Mar.02, Oct.03, Apr.04, Nov.04, Apr.05, Garroch Head - Nov.04, Kilbrannan Sound - Nov.04, Campbeltown Loch - Jan.01.

This species, which often has a conspicuous dark ring pattern on the scales (Fig. 4), is sometimes confused with *M. arenicolae* and *M. marphysae* which may be similar in appearance. In Scottish waters *M. andreapolis* is known from St. Andrews, Fife, and the Clyde. According to Chambers & Muir (1997) it may inhabit the burrows of Sea Cucumbers (*Labidoplax* and *Leptosynapta*). Although the routine sieving of mud samples would break up holothurian burrows and separate any scaleworms, in all of the above surveys these holothurians were frequently found in the sieve residue of same samples as *M. andreapolis*.

Malmgrenia arenicolae (Saint-Joseph, 1888)
Greenock: Ironotter Point - Apr.92 (conf. S. Chambers), Cloch Point - May 2000, Rothesay - Jun.01, Irvine Bay - Aug.95, Oct.03, Girvan - May 01 (coll. J. Hunter), Oct.02, Campbeltown - Jan.01(conf. S.Chambers), Nov.04.

This and the preceding species have previously been confused with *M. lunulata* which appears to be restricted to the Mediterranean (Barnich & Fiege, 2001). The first confirmed finds from the Clyde Sea Area originate from Clark & Dawson (1963) under the name "*Harmothoe joubini*". Elsewhere in Scotland it has been confirmed from St. Andrews but is likely to be more widespread. *M. arenicolae* is known to inhabit burrows or tubes of polychaetes sueh as *Arenicola marina* or *Neoamphitrite figulus*. One of the above specimens, collected from Irvine Bay in 1995, was found inside the tube of a Sand Mason worm (*Lanice conchilega*), while another from Ironotter Point in 1998 was found in the tube of *Amphitrite cirrata*. These latter scaleworms are deposited in the National Museum of Scotland (NMSZ.1998.063).

Malmgrenia castanea McIntosh, 1876
Sound of Jura – Aug.10, 1 at Stn. 10km W. of Bellochantuy Bay (conf. S.Chambers).

In Scottish waters *M. castanea* is previously known only from Shetland and the Moray Firth. It is very similar to *M. arenicolae*. They are distinguished by the secondary tooth on the neurochaeta. In *M. arenicolae* the tooth is conspicuous, while in *M. castanea* the tooth is considerable reduced and often difficult to discern (see Figs. 45 and 49, Tebble & Chambers 1982).

Malmgrenia furcosetosa Loshamn, 1981
Loch Eil - Aug.01, Greenock: Ironotter Point - Apr.92 (conf. S.Chambers), May 98,
Irvine Bay - Sep.89, Oct.92, Sep.98, Oct.98 (conf. S.Chambers).

M. furcosetosa was only recognised as a species in 1981, characterised by its furcate notosetae. However as the chaetal tips are sometimes covered in detritus it is easy to confuse with other *Malmgrenia* species. In Scottish waters it is known from the Firth of Clyde and Loch Etive. Elsewhere it has been recognised from Plymouth and the Skagerrak.

Malmgrenia glabra (Malmgren, 1865)
Sound of Jura – Jun.07, Greenock: Ironotter Point - Apr.92, Cloch Point - Apr.93, Apr.99 (conf. S.Chambers), Irvine Bay - Sep.89, Oct.92, Aug.95, Ayr Bay - Oct 92, Oct.03, Campbeltown Jan.01.

Malmgrenia ljungmani (Malmgren, 1867)
Irvine Bay - Oct.03, 1 at Stn. IVS-100m E. (Conf. S. Chambers)

Chambers & Muir (1997) highlight the similarity of *M. glabra* and *M. ljungmani* and utilise the arrangement of the papillae on the margin of the scales and the curvature of the lower neuropodial chaetae to separate the two species. The shapes of the bifid tips of the neuropodial chaetae, as shown in Tebble & Chambers (1982), may also be a helpful character. In Scottish waters *M. glabra* is known from the Firths of Clyde and Forth and from St. Andrews. *M. ljungmani* has been recorded from the Shetlands, the Outer Hebrides, and St. Andrews. Although only a single specimen of *M. ljungmani* (3mm for 20 setigers) has been observed in this study it has probably been overlooked due to confusion with other *Malmgrenia* species.

Malmgrenia marphysae (McIntosh, 1876)
Loch Creran: Barcaldine Jun.97, Aug.04, South Shian Aug.01, Greenock: Ironotter Point - May 89, Apr.92, May 95, May 98, Gareloch Oct.98, Cloch Point - Apr.93, Apr.99, May 2000, Apr.04, Rothesay Jun.01, Fairlie Dec.90, Irvine Bay - Sep.89, Oct.90, Oct.92 (conf. S.Chambers), Feb.93, Aug.94, Aug.95, Sep.98, Oct.98, Apr.99, Oct.99, May 2000 Apr.01, Apr.03, Oct.03, Jun.06, Ayr Bay Sep.89, Girvan Apr.92 (conf. S. Chambers), Aug.98, Campbeltown Jan.01, Nov.04.

The records above suggest *M. marphysae* is widely distributed in south west Scotland, although Chambers & Muir (1982) cited it only from Loch Eil. It is possible that some of the records here may refer to *M. arenicolae* with which it may be confused. *M. marphysae* is known to associate with a variety of tube dwelling or burrowing invertebrates.

Malmgrenia mcintoshi **Tebble & Chambers, 1982**
Greenock: Ironotter Point - May 95, 1 at C750, 2 at Stn. H750, Irvine Bay – Oct.98, 1 at Stn. 28, Jun.06, 2 at Stn. 9a, Girvan - May 01 (several collected by J. Hunter), Girvan – Sep.05, 2 at Grant's Stn. 10 (conf. S.Chambers).

The anterior fold on the scales of *M. mcintoshi* provides an excellent diagnostic feature. *M. mcintoshi* was only recognised as a distinct species by Tebble & Chambers (1982). Initially it was only confirmed from the Shetlands and the Isle of Man, but Chambers and Muir (1997) extended its known distribution to the Clyde Sea Area (including some of the records above), as well as to the Celtic Sea and Galway Bay. The specimens from Irvine Bay (Jun.06) had a conspicuous light-spotted pattern on the scales (Fig. 5).

Polynoe scolopendrina Savigny, 1822
Loch Ryan - Oct.94, 1 at Stn. 3, 2 at Stn. 4, Loch Creran: South Shian - Aug.01, 1 at Stn.5 (conf. S.Chambers).

P. scolopendrina is usually recognised by the absence of scales on the posterior of the body. Where the posterior is missing the species can be identified by its distinctive neurochaetal bundles which comprise 1 or 2 stout unidentate chaetae (usually uppermost) and below this a number of slightly less robust chaetae with clearly bidentate tips. *P. scolopendrina* is previously known in Scottish waters from Loch Torridon, Loch Maddy in the Outer Hebrides, Loch Creran, and off Cumbrae in the Inner Firth of Clyde.

Family Acoetidae
Panthalis oerstedi Kinberg, 1855
Loch Eil - Jun. 2009, 2 at "Surveillance site"
Loch Linnhe - Aug. 2001, 1 at Stn. "Lismore Deep".
This large scaleworm is easily recognised by the presence of brush-tipped chaetae and distinct pockets on the outer margin of the scales. The above specimens were around 8cm long and were each recovered from a membranous tube in soft mud. *P. oerstedi* is known from the Shetlands, Loch Nevis (see McIntyre, 1961), Loch Etive, Loch Fyne, and off Arran in the Firth of Clyde. The L. Linnhe specimen is deposited in the National Museum of Scotland (NMSZ.2009.135.01).

Family Pholoidae
Pholoe baltica Oersted, 1843 [as *P. inornata* Johnston, 1839 in Chambers & Muir, 1997]

Loch Eil - Aug.01, North Loch Linnhe - Aug.02, Loch Creran: Barcaldine - Jul.99, Aug.01, Aug.04, South Shian - Aug.01, Mull: Tobermory - Aug.01, Sound of Jura – Jun.07, Inner Firth of Clyde: Ardmore - Oct.98, Gareloch Oct.98, Greenock: Ironotter Point - May 98, Cloch Point - Apr.99, May 2000, Mar.02, Apr.03, Apr.04, Apr.05, May 06, Feb.07, Rothesay - Jun.01, Garroch Head - Nov.2000, Irvine Bay - Sep.98, Oet.98, Oct.99, Apr.03, Oct.03, Apr.04, Nov.04, Apr.05, Jun.06, Kilbrannan Sound -Nov.04, Girvan - Aug. 98, Aug. 2000, Oct.02, Campbeltown Jan.01, Nov.04, Loch Ryan - Aug.04.

Pholoe inornata Johnston, 1839 [as *P. synophthalmica* Claparède, 1868 in Chambers & Muir, 1997]
Loch Eil - Aug.01, North Loch Linnhe - May 02, Loch Creran: Barcaldine - Jul. 99, Aug.01, Aug.04, South Shian - Aug.01, Mull: Tobermory - Aug.01, Greenock: Ironotter Point - May 98, Gareloch - Oct.98, Rothesay Jun.01, Garroch Head - Nov.04, Irvine Bay - Oct.98, Oct.99, Oct.03, Nov.04, Jun.06, Girvan - Aug.98, Oct.02, Campbeltown - Jan.01, Nov.04, Loch Ryan - Sep.99, Aug.2000, Aug.04.

There has been considerable nomenclatural confusion regarding *Pholoe* species in UK waters. Chambers (1985) recognised only *P. inornata* and a new eyeless species which she named *P. pallida*. In Chambers & Muir (1997) a third species, *P. synophthalmica,* was separated from *P. inornata*. The following year Petersen (1998) reviewed the nearshore species of *Pholoe* in Northern Europe recognising four valid species from British waters. The "*P. inornata*" of Chambers & Muir (1997) was referred to *P. baltica*, whilst their "*P. synophthalmica*" was regarded as the true *P. inornata* Johnston, 1839. This latter view was subsequently confirmed by Barnich & Fiege (2003). In addition Petersen resurrected another old species, *P. assimilis* Oersted, 1845, which is very similar to *P. inornata*. The present note only includes records from 1998 onwards as older records may be inaccurate.

Surprisingly Clark (1960) only has a single record of *Pholoe* (as "*P. minuta*") from the Clyde Sea Area, while Clark & Dawson (1963) cite nine specimens from Millport under the name "*P. synophthalmica*" and comment in detail on the nomenclatural confusion. Comely (1973) describes "*P. minuta* – form *synophthalmica* Claparède" as frequent at Toment End, Cumbrae. It is evident from the numerous records here that both *P. baltica* and *P. inornata* are widely distributed in the Clyde & Argyll Sea Area. They frequently occur in the same survey areas and sometimes in the same grab samples. The length of the papillae on the scales helps distinguish them. *P. assimilis* has not yet been found in the Clyde Sea Area though it has recently been found in Scottish waters at Kingstone Hudds in the Firth of Forth (Lee Heaney, SEPA South East Area, *pers comm.*). However, as *P. inornata* and *P. assimilis* are very similar, it is possible that the occurrence of the latter species has been overlooked.

Family Sigalionidae
Sigalion mathildae Audouin & Milne-Edwards in Cuvier, 1830
Rothesay - Jun.01, Fairlie - Dec.90, Irvine Bay - Sep.89, Oct.92, Aug.95, Oct.99, Ayr Bay - Sep.89, Oct.92.

A widespread species on Scottish shores. The bipinnate papillae on the scales make this an easy species to identify although a similar species, *S. squamosum*, with fewer pinnules is also now confirmed from North Unst and the Shetlands (Chambers & Muir, 1997).

Sthenelais boa (Johnston, 1833)
Sound of Jura - Jun.07, Rothesay - Jun.01, Irvine Bay - Sep.89, Feb.93, Jun.06, Girvan - Aug.98, Aug.2000, Campbeltown Jan.01, Loch Ryan - Oct.91, Oct.93, Nov.96, Aug.97, Sep.99, Aug.2000, Aug.04.

Sthenelais limicola (Ehlers, 1864)
Loch Eil - Aug.01, Sound of Jura - May 06, Jun. 07, Greenock: Ironotter Point - May 89, Apr.92, North of Cumbrae - Mar.96, Cloch Point - Apr.01, Largs - Dec.90. Irvine Bay - Sep.89, Oct.92, Aug.95, Sep.98, Oct.98, Oct.99, Oct.03, Nov.04, Ayr Bay - Sep.89, Oct.92, Kilbrannan Sound- Nov.04.

Both the above *Sthenelais* species are widespread in Scottish coastal waters. *S. boa* frequently has sand grains adhering to its scales. The notched posterior scales in *S. limicola* act as a quick identification feature. A third species, *S. zetlandica*, which lacks the unjointed spiny neuropodial chaetae, has been recorded from the Shetlands and also from the Irish Sea (Chambers & Muir, 1997).

New records of Parasitic Copepods from Scaleworms in the Clyde an Argyll Sea Area
Two quite different copepod families parasitise scaleworms (see Gotto, 2004). The Nereicolids, represented by the genus *Selioides*, are moderately transformed ectoparasites with recognisable head and body regions with cephalic appendages, including conspicuous maxillipeds and two pairs of legs. The herpyllobiids, on the other hand are grossly transformed mesoparasites with the female divided into two body regions: an irregular shaped endosomal portion inside the host and attached by a stalk to a globular exosomal portion outside the host which is devoid of any appendages. The only indication of their copepodan nature is the presence of a pair of large ovisaes in ovigerous females or the attachment of dwarfed male copepodites to the female genital area. The Herpyllobiids were studied in some detail in a series of papers by Lutzen (1964, 1966, 1968).

New records of parasitic copepods associated with individual scaleworm specimens collected in the area are cited below:

(a) Irvine Bay (1981?), Stn. R2 - *G. cirrhosa* with a single juvenile *Selioides bocqueti* Carton, 1963, attached to the dorsum at setiger 8/9. The juvenile copepod is 0.35mm long and resembles the copepodite "Stage A" figured by Carton (1964). Remnants of a large pair of copepod maxillipeds embedded on the dorsum of the same scaleworm, just behind the prostomium, indicate an adult female copepod had also been attached.

S. bocqueti has been recorded in the southern Irish Sea (O'Reilly, 1995) and off the coast of Northumberland (O'Reilly & Geddes, 2000). A similar species, *S. bolbroei* Levinsen, 1878 was reported from Loch Fyne by Scott in 1901 (under the name *Cancerina confusa*). Scott's single female specimen was found among dredge debris, detached from any host.

In June 1986, two specimens of *S. bolbroei* (an adult and a juvenile female) were recovered by M.O'Reilly attached to a *G. cirrhosa* collected from off St. Abbs (Stn. 27) in the Firth of Forth. The adult female specimen is illustrated *in-situ* in Figure 20 of Chambers & Muir (1997). There are no other records of *S. bolbroei* in British waters, but it is also known from Denmark, Sweden, Iceland, Greenland, Canada, and the Kara Sea (see Bresciani, 1967).

(b) Irvine Bay Sep. 87, Stn. Z - *G. cirrhosa* with 2 ovigerous female *Herpyllobius arcticus* Steenstrup & Lutken, 1861, on posterior parapodia.

This copepod may have previously been recorded in the Clyde Sea Area by Clark (1960), under the name "*Hedyphanella superba*", on the dorsum of a *G. cirrhosa* specimen from Etterick Bay. However see note (d) below for a possible alternative identification. Clark's simultaneous reference to a parasitic copepod attached to the prostomium of the same host specimen undoubtedly refers to *Herpyllobius polynoes* (Kroyer, 1863) which exclusively attaches in this location.

(c) Cloch Point, May 2007, Stn. CMT7 - *G. cirrhosa* with 1 ovigerous female *Eurysilenium truncatum* M.Sars, 1870 (with 2 dwarf males attached to female copepod), on posterior dorsum (setiger 22) of scaleworm host (Fig. 6) .

(d) Cloch Point, May 2007, Stn. CMT7 - *G. cirrhosa* with 1 mature female *Eurysilenium truncatum* M.Sars, 1870 (with 1 dwarf male attached to female copepod), on posterior dorsum (setiger 19) of scaleworm host. This scaleworm also had 2 immature female *Herpyllobius polynoes* attached to the prostomium resembling the example of double parasitism described by Clark (see (b) above). It is possible that Clark's "*Hedyphanella superba*" on the dorsum of *Gattyana* may actually have been *E. truncatum* (rather than *H. arcticus*) as the two species are very similar in appearance.

The two scaleworms from Cloch Point parasitized by *E. truncatum* (and *H. polynoes*) were both collected from a single Day Grab sample. Until now *E. truncatum* has only been observed in Scandinavian waters and the above specimens represent the first confirmed records from British waters. A subsequent find of an ovigerous *E. truncatum* from *G. cirrhosa* collected in the East Shetland Basin was recently presented to the author (Fig.7). Note that the reference in Chambers & Muir (1997) to *E. truncatum* from Plymouth is erroneous.

(e) Garroch Head, Nov.2000, Stn.T7 - *H. antilopes* with an ovigerous female *Herpyllobius polynoes* (Kroyer, 1863), attached to its prostomium. In addition to the record (see (d) above) from *G. cirrhosa* this copepod has also been observed attached to *G. cirrhosa* from the Firth of Forth (see O'Reilly, 1999).

(f) Irvine Bay, Sep.1981, Stn. H - specimen of *M. andreapolis* with an ovigerous female copepod, referred to *Herpyllobius polynoes* (Kroyer, 1863), attached to its prostomium. This specimen is illustrated, in-situ in Figure 34, of Chambers & Muir (1997). Since then three specimens of this copepod have been collected on *M. andreapolis* from the same locality in Irvine Bay. These included another ovigerous female in April 2001 and an ovigerous female and a mature female on a single host in April 2005. Provisional examination of these copepods and similar copepods on *M. andreapolis* in the Firth of Forth, the Solway Firth, and the Irish Sea suggests that the ectosomal body shape differs somewhat from *H. polynoes* and may represent a new species particular to this host. This will be the subject of a subsequent study.

New records of entoprocts and other epizoans associated with Scaleworms in the Clyde and Argyll Sea Area

Records from individual scaleworm specimens are cited below:

a) Garroch Head Sewage Sludge disposal grounds, 1971 – *Gattyana cirrhosa* with 25 entoprocts, *Loxosomella compressa* Nielsen & Ryland, 1961 on chaetae (Fig. 8).
b) Irvine Bay, Sep.89 - *G. cirrhosa* with 13 entoprocts, *Loxosomella harmeri* (Schultz, 1895) and 2 stalked ciliate colonies (cylindrical colony shape resembling *Zoothamnium niveum*) on scales and 20 entoprocts, *Loxosomella compressa* Nielsen & Ryland, 1961 on chaetae.
c) Irvine Bay, Aug.91, Stn.Z - *G. cirrhosa* with 8 hydroid polyps, *Leuckartiara octona* (Fleming, 1823) on posterior scales.
d) Irvine Bay, Aug.95 Stn.H - *G. cirrhosa* with 20 entoprocts, *Loxosomella harmeri* (Schultz, 1895), and 15 stalked ciliate colonies, resembling *Zoothamnium niveum*, (Fig. 9) on scales.
e) Loch Eil, Jun.09, Surveillance site – 3 entoprocts, *Loxosomella glandulifera* Franzén, 1962 recovered from within the tube of *Panthalis oerstedii*.

Entoprocts and other small epizoans are generally over-looked and under-recorded by marine ecologists. *Loxosoma compressa* is known to attach to the chaetae of a variety of polynoid scaleworms (and is also found within *Chaetopterus* tubes) in British waters (Cullercoats and the Isle of Man) as well as Norway and Denmark. *L. harmeri* has a rather similar distribution and occurs on the elytra, antennae, and cirri of polynoid scaleworms (and also in *Chaetopterus* and *Amphitrite* tubes). The entoproct *Loxosomella glandulifera* is previously known only from the Skagerrak and the Kattegat and is newly recorded from British waters. It attaches to the filaments on the inside of its hosts tube. It can be quite difficult to find among the tube filaments and the tube was stained in Rose Bengal solution in order to help highlight any entoprocts present. The hydroid *Leuckartiara octona* and ciliate colonies, such as *Zoothamnium sp.*, are widely distributed and can be found on a variety of substrates.

New records of entoprocts and other epizoans associated with the sea mouse (*Aphrodita aculaeta*) in the Clyde and Argyll Sea Area

In April 2009 during a fish trawling survey in the Gareloch ten adult sea mice were collected to search for associated epizoa. The sea mice ranged in size from 6.5 to 9cm long and were preserved in formosaline before return to the laboratory for microscopical examination. The ventral sole, parapodia, and lateral masses of spines and hairs were checked for epizoans. The dorsal hair mass was cut open along the midline to reveal the large scales and the galleries beneath the scales were searched.

Although Neilsen (1989) highlights three different solitary entoproct species of *Loxosomella* from *A. aculeata*, none of these were observed on the Gareloch specimens. All the specimens had some colonies of the hydroid *Leuckartiara octona* (Fleming, 1823). The hydroid zooids were most abundant ventrally, attached to the fine lateral hairs and to the parapodia. In some sea mice small *L. octona* zooids also occurred on the ventral sole. One sea mouse harboured a small colony (20 zooids) of the bryozoan *Triticella pedicellata* (Alder, 1857) on the underside of one of its scales. Around 20 individual zooids of *T. pedicellata* were also observed scattered on the sole of a second sea mouse (along with numerous individual stalked ciliates). On the sole of a third sea mouse were a few *L. octona* zooids and 2 zooids of the entoproct *Barentsia elongata* (M.Sars, 1835). Finally on the sole of a fourth sea mouse were numerous *L. octona* zooids, around 40 zooids of a small athecate hydroid, about 0.5mm tall (Fig. 10), and 10 zooids of the entoproct *B. elongata*. In addition this sea mouse also had a colony (70 zooids) of the bryozoan *T. pedicellata* on the underside of one of its scales. This last specimen is deposited in the National Museum of Scotland.

The association of the hydroid *Leuckartiara octona* (Fleming, 1823) with *A.aculeata* is well known and was studied in the Clyde Sea Area by Latham (1962). It appears that the sea mouse is infested only in areas with muddy bottoms and Latham suggests that the hydroid planula larvae utilise the bristles of the sea mouse as an appropriate settlement location in an area otherwise devoid of hard substrata. Stechow (1929) and Leloup (1934) highlight a variety of hydroids and other epizoa from *A.aculeata* although of the hydroids only the athecate species *L. octona* and *Hydractinia borealis* (Mayer, 1900) (see Schuchert 2008 for synonymy) seem to occur regularly.

Records of *T. pedicellata* are rather scarce and it is not previously known from *A. aculeata*. Its congener *Triticella flava* Dalyell, 1848, which occurs on the burrowing shrimp *Calocaris macandreae* Bell, 1846, is perhaps better known and has been observed by us on *C. macandreae* from Irvine Bay and from *Nephrops norvegicus* collected near Rothesay.

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Plate 1

(1). *Harmothoe imbricata* – showing cylindrical macrotubercles on posterior edge of scales.

(2). *Harmothoe pagenstecheri* – showing antler-like macrotubercles on posterior edge of scales.

(3). *Harmothoe pagenstecheri* – showing ovoid macrotubercles on posterior edge of scales.

(4). *Malmgrenia andreapolis* – showing conspicuous dark ring pattern on scales.

(5). *Malmgrenia mcintoshi* – showing conspicuous light-spotted pattern on scales.

(6). Parasitic copepod, *Eurysilenium truncatum*, ovigerous female attached to *G. cirrhosa* from off Cloch Point in the Firth of Clyde (Ov.= Ovisac, Co.= Copepod).

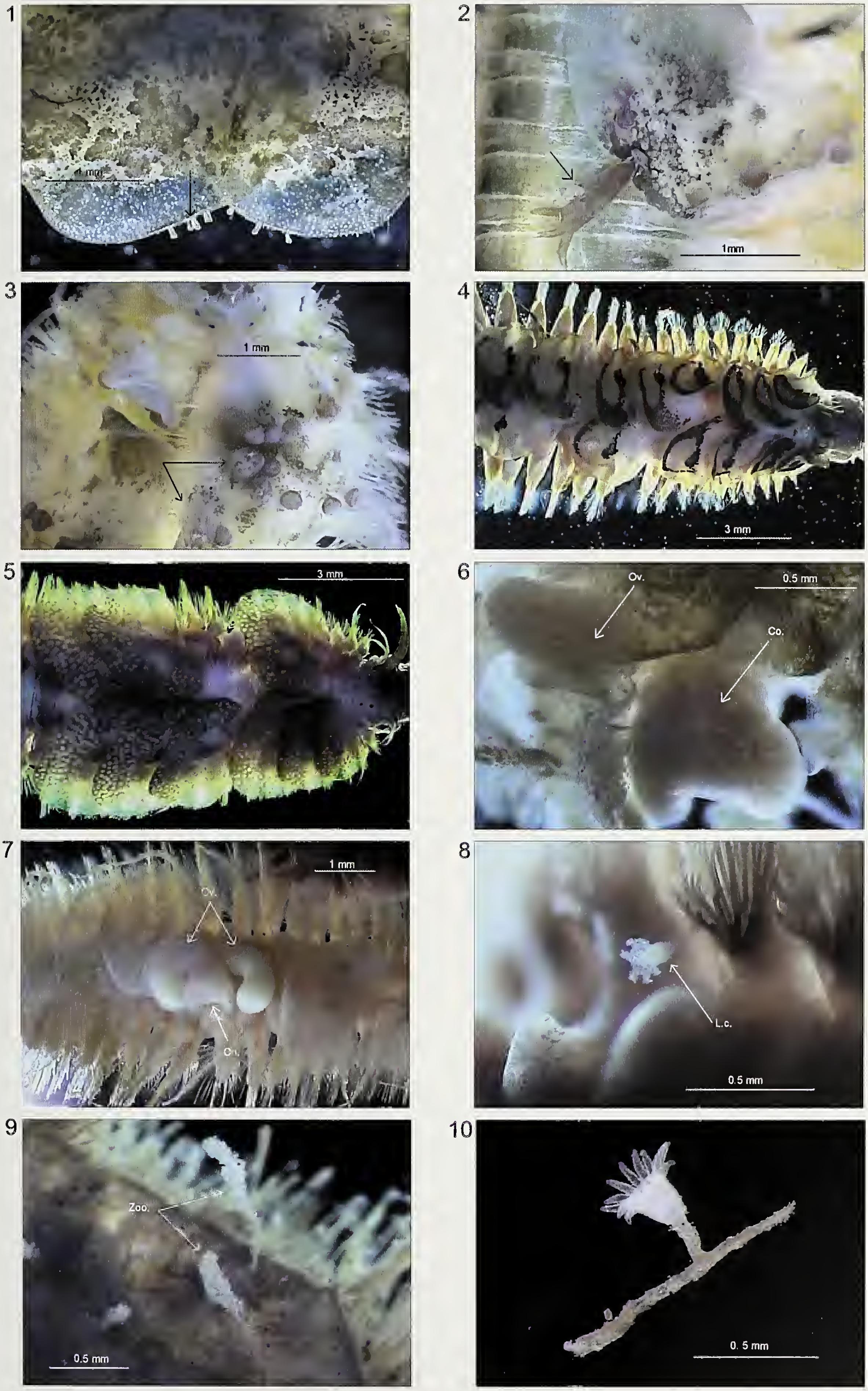
(7). Parasitic copepod, *Eurysilenium truncatum*, ovigerous female attached to *G. cirrhosa* from East Shetland Basin (Ov.= Ovisacs, Co.= Copepod).

(8). Entoproct, *Loxosomella compressa* (= L.c.), attached to neurochaeta of *G. cirrhosa* from Garroch Head disposal grounds.

(9). Ciliate colonies, *Zoothamnium niveum*?, attached to scales of *G. cirrhosa* from Irvine Bay.

(10). Small athecate hydroid from sole of *Aphrodita aculeata*, collected in the Gareloch.

Plate 1


1
2
1mm
3
1 mm
4
3 mm
5
3 mm
6
Ov.
0.5 mm
Co.
7
1 mm
Ov.
8
L.c.
0.5 mm
9
Zoo.
0.5 mm
10
0. 5 mm

Appendix 1. Station Details (arranged by survey area approximately North to South)

Loch Eil, Surveillance site, 56°50.93'N, 05°14.73'W, depth 36m
Loch Linnhe, Lismore Deep, 56°34.80'N, 05°28.30'W, depth 109m
Loch Creran, South Shian, Stn. 5, 56°31.25'N, 05°23.86'W, depth 7m
St. Abbs Head (Forth Sea Area), Lothian Region Council disposal grounds, Stn. 27 - 56°05.91'N, 02°04.72'W, depth 52m
Kingstone Hudds, Firth of Forth, 56 °07.44' N, 02 °55.92' W, depth 40m.
Port Glasgow, Stn. 18 miles, 55°56.28'N, 04°40.26'W, depth 8m
Cloch Point, Stn.CMT7, 55°56.85'N, 04°53.65'W, depth 81m
Greenock, Ironotter Point, Stn. B2, 55°58.50'N, 04°48.81'W, depth 28m
Greenock, Ironotter Point, Stn. F1, 55°58.30'N, 04°48.13'W, depth 20m
Greenock, Ironotter Point, Stn. C750, 55°58.73'N, 04°48.30'W, depth 25m
Greenock, Ironotter Point, Stn. H750, 55°57.99'N, 04°48.71'W, depth 25m
Firth of Clyde, East of Toward Point (UIFM2), 55°52.08'N, 04°56.70'W, depth 37m
Rothesay Creamery, Stn. 100ms, 55°50.62'N, 05°01.24'W, depth 28m
Garroch Head, Stn. T7, 55°38.82'N, 05°01.45'W, depth 139m
Irvine Bay, Stn. C, 55°33.60'N, 04°43.95'W, depth 36m
Irvine Bay, Stn. H, 55°35.92'N, 04°47.40'W, depth 38m
Irvine Bay, Stn. I, 55°36.72'N, 04°46.55'W, depth 29m
Irvine Bay, Stn. P, 55°35.30'N, 04°44.45'W, depth 25m
Irvine Bay, Stn. R1, 55°34.05'N, 04°40.55'W, depth 9m
Irvine Bay Stn. R2, 55°33.88'N, 04°41.65'W, depth 13m
Irvine Bay, Stn. Z, 55°34.75'N, 04°45.20'W, depth 40m
Irvine Bay, Stn. 5, 55°35.19'N, 04°41.40'W, depth 6m
Irvine Bay, Stn. 9a, 55°34.90'N, 04°41.49'W, depth 6m
Irvine Bay, Stn. 28, 55°35.43'N, 04°41.88'W, depth 6m
Irvine Bay, Stn. 19, 55°35.24'N, 04°41.59'W, depth 6m
Irvine Bay, Stn. IVS - 100m E, 55°34.88'N, 04°42.99'W, depth 6m
Sound of Jura, Stn. 10km W.of Bellochantuy Bay, 55°31.735'N, 05°52.217'W, depth 67m
Campbeltown, Stn. 8, 55°25.65'N, 05°34.03'W, depth c.3m
Campbeltown, Stn. 10, 55°25.69'N, 05°33.96'W, depth c.3m
Campbeltown, Stn. 11, 55°25.61'N, 05°33.98'W, depth c.3m
Girvan, Grant's Stn. 10, 55°16.152'N, 04°51.431'W, depth c.10m
Girvan, Grangestone, Stn. 1, 55°15.43'N, 04°51.67'W, depth e.5m
Girvan, Grangestone, Stn. 2, 55°15.92'N, 04°51.63'W, depth c.5m
Girvan, Grangestone, Stn. 3, 55°15.70'N, 04°51.73'W, depth c.5m
Girvan, Grangestone, Stn. 5, 55°15.60'N, 04°51.68'W, depth c.5m
Girvan, Grangestone, Stn. 6, 55°15.52'N, 04°51.67'W, depth c.5m
Girvan, Grangestone, Stn. 7, 55°15.63'N, 04°51.32'W, depth c.5m
Girvan, Grangestone, Stn. A2, 55°15.41'N, 04°51.92'W, depth c.10m
Girvan, Grangestone, Stn. B2, 55°15.52'N, 04°51.84'W, depth c.10m
Girvan, Grangestone, Stn. C2, 55°15.63'N, 04°51.84'W, depth c.10m
Loch Ryan, Stn. WQ7, 54°58.44'N, 05°02.24'W, depth 10m
Loch Ryan, Stn. 3, 54°55.15'N, 05°00.96'W, depth c.5m
Loch Ryan, Stn. 4, 54°55.30'N, 05°00.67'W, depth c.5m
Loch Ryan, Stn. 7, 54°55.20'N, 05°00.55'W, depth c.5m

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Upland grassland Auchenorrhyncha at Glen Finglas, Perthshire

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ABSTRACT

Sweep-netting and D-vac suction sampling of Auchenorrhyncha (leafhoppers, planthoppers and related groups) was carried out at Glen Finglas in June and July 2007. Thirty three species were identified and these included *Paraliburnia clypealis* and *Paradelphacodes paludosa* which are both apparently new to Scotland. Also recorded were *Oncopsis subangulata* for which we know of just one previous Scottish record and an additional seven species that are scarce or local in the UK. A disproportionate number of the scarcer species were found in D-vac suction samples suggesting they may have been previously overlooked by more conventional sampling methods.

INTRODUCTION

Auchenorrhyncha (leafhoppers, planthoppers and related groups) can be abundant insects in grassland systems. Due to their numerical dominance they are a group that can have large functional significance as herbivores and as vertebrate and invertebrate prey items (Biedermann *et al.* 2005). They are entirely phytophagous insects that are usually closely associated with a narrow range of host foodplants. Hence Auchenorrhyncha assemblages can sensitively reflect land cover (Eyre *et al.*, 2001; Eyre *et al.*, 2005) and may therefore be a useful study group in assessments of management practices (e.g. Fisher Barham and Stewart 2005; Littlewood *et al.*, 2006a; Littlewood *et al.*, 2006b).

At Glen Finglas, Perthshire, a randomized replicated experiment was established in 2002/03 to investigate cascading trophic interactions of different grazing levels within an upland grassland system. Sampling of insects has shown strong responses of overall abundances and of species functional groups within different orders to different grazing treatments (Littlewood 2008; Dennis *et al.*, 2008). Here, we present a summary of the species found at Glen Finglas including discussions on records that are significant in a Scottish context. The response of Auchenorrhyncha assemblages to grazing treatments is being published elsewhere (Littlewood *et al.*, in press).

METHODS

Study Site

Glen Finglas, Perthshire, Scotland, is a 4085 ha estate grazed by sheep and cattle. A replicated, randomised block experiment was established consisting of 24 plots, each measuring 3.3 ha, with four treatments and six replicates. Littlewood (2008) and Dennis *et al.* (2008) give further details of the experimental set-up and treatments. Plots ranged in altitude from 220 m to 500 m. The dominant vegetation was acid grassland and mire. The most represented National Vegetation Classification (NVC) communities were M23 (*Juncus effusus/acutiflorus–Galium palustre* rush-pasture), M25 (*Molinia caerulea–Potentilla erecta* mire), U4 (*Festuca ovina–Agrostis capillaris–Galium saxatile* grassland) and U5 (*Nardus stricta–Galium saxatile* grassland). Some areas were covered by bracken fern (*Pteridium aquilinum*, NVC group U20). A small number of isolated trees grew in lower plots comprising downy birch *Betula pubescens*, eared willow *Salix aurita* and rowan *Sorbus aucuparia*, while some plots had substantial patches of the shrub bog myrtle *Myrica gale*.

Sample Collection

Samples were collected between 1 June and 9 July 2007 from up to five randomly chosen locations within each plot. Two sampling methods were used: D-vac and sweep-netting. The D-vac (D-vac co., Ventura, California, USA) takes standard suction samples through a funnel with diameter of 34.3 cm. Samples at each location consisted of five pooled sub-samples of duration 45 seconds each. Sweep-netting was carried out along a 20 m × 0.5 m transect running north from the sample point. For further details see Dennis *et al.* (2008).

Auchenorrhyncha were identified, by dissection of genitalia where necessary, using Biedermann and Niedringhaus (2004) and Holzinger *et al.* (2003). Nomenclature follows Biedermann and Niedringhaus (2004). For potentially noteworthy species, Scottish records were extracted from the UK Auchenorrhyncha Recording Scheme.

RESULTS
In total 3319 adult Auchenorrhyncha were caught with 1244 collected by D-Vac and 2075 by sweep net. Of these 2310 were identified to a total of 33 species. Females of Delphacidae (1002 individuals), Cixiidae (6 individuals) and Aphrodinae (1 individual) were not identified to species (Table 1).

Two species, *Paraliburnia clypealis* and *Paradelphacodes paludosa* appear to be new species for Scotland. There is only a single previous Scottish record of a further species; *Oncopsis subangulata.* Seven additional species are classified in the UK as either "Local" or "Notable" with three of these each having just two previous Scottish records (Table 2).

DISCUSSION
Species richness of adult Auchenorrhyncha in Scotland usually peak somewhat later in the year than the sampling period covered by this study. Hence the results presented here are likely to represent a sub-set of grassland species present at the site. However the number of nationally rare and scarce species recorded indicates the potential for such sampling to add significantly to our knowledge of the Scottish fauna.

Paraliburnia clypealis
With fifty-six individuals identified this was the tenth most abundant species in the samples. It is the most surprising of the species caught. Until 1980 it was known in Britain only from Wicken Fen, Cambridgeshire but has since been recorded from fens in Norfolk, Huntingdonshire and Somerset (Kirby 1992). There is however a previous report in Scotland as Kirby (1992) lists Cally Pallace, Kircudbrightshire, as a location for this species though we have no further information on this record. *P. clypealis* was thought to be restricted to acid wetlands and to feed primarily on *Calamagrostis canescens* (Nickel and Remane 2002; Biedermann and Niedringhaus 2004) though apparent associations have been reported in the Netherlands with *Rhynchospora* spp. and *Eriophorum* spp. (Nickel 2003). However a population was recently found in Ireland in field margins within dairy grassland and although the foodplant was not identified there it was thought likely to be one of the common grasses such as *Agrostis* sp., *Alopecurus geniculatus*, *Dactylis glomerata*, *Holcus lanatus*, *Holcus mollis* or *Lolium perenne* (Helden and Sheridan 2006). The foodplant used at Glen Finglas is not known but *Calamagrostis canescens* is absent from the glen and *Rhynchospora* spp. and *Eriophorum* spp. are absent in the vicinity of the sample points. The British status of *P. clypealis* is listed as "insufficiently known" (Kirby 1992).

Paradelphacodes paludosa
This species inhabits wetlands, especially sphagnum bogs, spring mires and fens (Nickel 2003). Nine individuals were recorded in this study: eight from D-vac sampling and one from sweep-netting. One D-vac sample, from a marshy part of the site, contained seven specimens indicating a local concentration. Kirby (1992) lists records from scattered counties in southern England and Wales and also Cumberland in northern England. We know of no previous Scottish records. The species is thought to feed on *Carex.* sp. (Biedermann and Niedringhaus 2004), possibly *C. rostrata* or *C. panicea* (Nickel and Remane 2002) and lives very low in the vegetation and therefore may be under-recorded (Kirby 1992).

Oncopsis subangulata
A single male was sweep-netted. The species feeds on *Betula pendula* and *B. pubescens* (Claridge and Nixon 1986; Nickel and Remane 2002; Biedermann and Niedringhaus 2004). There are scattered stands of *B. pubescens* at Glen Finglas and this individual is presumed to have been displaced from one of these. Hence, the species may be more numerous at the site than this single record would indicate. Although not classified as notable or local in the UK, the only other Scottish record that we know of is of one in Aberdeenshire in 1970. However difficulties of identification within this genus may cause the species to be overlooked.

Seven further species recorded are classified as Notable or Local in the UK. The habitat requirements for the species vary but all can tolerate wet or, at least, damp sites as found at Glen Finglas. *Delphacinus mesomelas*, *Acanthodelphax denticauda*, *Dicranotropis divergens* and *Javesella forcipata* are essentially species of meadows that feed on grasses (Nickel 2003). Of these *D. mesomelas* can, in addition, be found on dryer sand sites including heaths whilst *A. denticauda* also occurs in forests (Eyre *et al.*, 2001; Nickel 2003). *Xanthodelphax straminea* is also a grass-feeder which is found across a range of meadows, mires and bogs. *Oncodelphax pullula* and *Nothodelphax distincta* are more typical species of mires, especially bogs and feed on sedges (Eyre *et al.*, 2001; Nickel 2003). The status of these species are detailed along with previously recorded Scottish locations in Table 2.

Overview
The Auchenorrhyncha are a very under-recorded insect group in Scotland and much remains to be discovered about the species that occur and their distributions. The specimens identified in this study comprised a few common species, such as *Neophilaenus lineatus*, *Javesella discolor and J. dubia*, which are typical constituents of a wide range of grasslands, especially non-intensively managed sites (e.g. Eyre *et al.*, 2001). The list also includes species such as *Macustus grisescens*, *Streptanus marginatus* and *Jassargus pseudocellaris* that are typical elements of upland sites and *Dikraneura variata* and *Verdanus abdominalis* which are especially typical of wetter grass moorland (Eyre 2005).

Identification of specimens collected at Glen Finglas has revealed a high proportion of apparently scarce and local species. Two of the species previously not recorded from Scotland, *Paraliburnia clypealis* and *Paradelphacodes paludosa*, were recorded primarily from D-vac samples (53 out of 56 and 8 out of 9

specimens respectively). This is in contrast to the pattern for the catch as a whole within which only 37% of specimens were collected by D-Vac. Because it is relatively inexpensive and easy to do, sweep-netting is probably the most widely used method for collecting herbivorous insects from vegetation (Stewart 2002). In this study, as well as catching more individuals, a greater number of species was recorded by sweep-netting (31) than with the D-vac (21). This is in contrast to other studies on grassland Auchenorrhyncha in which D-vac sampling produced the greatest abundance and species richness (e.g. Standen 2000). However some species that dwell close to the ground may be under-recorded if sweep-netting alone is used, giving a false impression of rarity. Indeed pitfall sampling for Auchenorrhyncha may reveal further species that are missed by more commonly applied sampling methods (Stewart 2002).

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Taxon	Sex	Quantity
Fulgoromorpha		
Cixiidae		
Cixius nervosus (L., 1758)	♂	1
Cixiidae sp. ♀		6
Delphacidae		
Delphacinus mesomelas (BOH., 1850)	♂	1
Paraliburnia clypealis (J.SHLB., 1871)	♂	56
Acanthodelphax denticauda (BOH., 1847)	♂	6
Nothodelphax distincta (FL., 1861)	♂	3
Dicranotropis divergens KBM., 1868	♂	2
Florodelphax leptosoma (FL., 1861)	♂	10
Xanthodelphax straminea (STÅL, 1858)	♂	9
Paradelphacodes paludosa (FL., 1861)	♂	9
Oncodelphax pullula (BOH., 1852)	♂	6
Criomorphus albomarginatus CURT., 1833	♂	20
Javesella discolor (BOH., 1847)	♂	310
Javesella dubia (KBM., 1868)	♂	158
Javesella forcipata (BOH., 1847)	♂	692
Delphacidae sp.	♀	1002
Cicadomorpha		
Aphrophoridae		
Neophilaenus lineatus (L., 1758)	♂ & ♀	301
Philaenus spumarius (L., 1758)	♂ & ♀	84
Cicadellidae - Ulopinae		
Ulopa reticulata (F., 1794)	♀	2
Cicadellidae - Macropsinae		
Oncopsis subangulata (J. SHLB., 1871)	♂	1
Cicadellidae - Aphrodinae		
Planaphrodes bifasciata (L., 1758)	♂	4
Aphrodinae sp. ♀		1
Cicadellidae - Cicadellinae		
Evacanthus interruptus (L., 1758)	♂	2
Cicadellidae - Typhlocybinae		
Dikraneura variata HARDY, 1850	♂ & ♀	31
Forcipata citrinella (ZETT., 1828)	♂ & ♀	5
Notus flavipennis (ZETT., 1828)	♂ & ♀	28
Eupteryx notata CURT., 1837	♂	1
Cicadellidae - Deltocephalinae		
Balclutha punctata (F., 1775)	♀	4
Macrosteles sexnotatus (FALL., 1806)	♂ & ♀	5
Deltocephalus pulicaris (FALL., 1806)	♂	5
Thamnotettix confinis (ZETT., 1828)	♂	5
Macustus grisescens (ZETT., 1828)	♂ & ♀	121
Streptanus marginatus (KBM., 1858)	♂ & ♀	196
Jassargus pseudocellaris (FL., 1861)	♂ & ♀	118
Jassargus sursumflexus (THEN, 1902)	♂	1
Verdanus abdominalis (F., 1803)	♂ & ♀	113

Table 1. Quantity and sex of adult Auchenorrhyncha species and selected genera and families recorded at Glen Finglas in 2007.

Species	UK status	Scottish Records (from UK Auchenorrhyncha Recording Scheme)
Delphacinus mesomelas	local	Fifeshire (Tentsmuir); Perthshire (Pitlochry)
Paraliburnia clypealis	Insufficiently known	none
Acanthodelphax denticauda	local	Perthshire (Perth). Morayshire (Nethy Bridge).
Nothodelphax distincta	local	Lanarkshire (North Bellstane Moor). West Lothian (Lochcote Marsh). Perthshire (Loch Monaghan; Lochan Buidhe). Moray (Abernethy; Craggan). Inverness-shire (Loch Garten). West Ross (Inverpolly).
Dicranotropis divergens	Nb	East Lothian (Camelshiel Castle). Midlothian (Edinburgh; Balerno). West Lothian (Faucheldean). Perthshire (Struan; Ballinluig Island). Aberdeenshire (Crathie Wood). Moray (Aviemore; Craigellachie; Granish; Grantown-on-Spey; Nethy Bridge). Invernesshire (Loch Garten; Northern Corries SSSI; Alvie).
Paradelphacodes paludosa	Nb	none
Xanthodelphax straminea	local	Morayshire (Nethy Bridge; Aviemore)
Oncodelphax pullula	Nb	Perthshire (Lochan Buidhe; Rannoch). Morayshire (Aviemore; Abernethy Forest). Invernesshire (Northern Corries SSSI). North Ebudes (Rum).
Javesella forcipata	local	Midlothian (Balerno); Perthshire (Logierait Pond, Ballinluig Island, Rannoch, Killin, Kindrogan); Moray (Craigellachie, Aviemore, Nethy Bridge, Grantown-on-Spey); Invernesshire (Loch Garten); Rum; West Ross (Beinn Eighe, Inverpolly); East Ross (Moniack Burn)
Oncopsis subangulata		Aberdeenshire (Dinnet).

Table 2. UK status and previous Scottish records of noteworthy Auchenorrhyncha species recorded at Glen Finglas in 2007. Nb means "Nationally Scarce category B" and indicates species thought to occur in fewer than 100 ten km squares in the UK.

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Recording butterfly distribution and habitat characteristics in Glen Creran using a global positioning system device

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ABSTRACT

Two UK Biodiversity Action Plan (BAP) Priority butterfly species, chequered skipper, *Carterocephalus palaemon* and pearl-bordered fritillary, *Boloria euphrosyne* which inhabit woodland glades occur at Glen Creran Woods Site of Special Scientific Interest near Oban. The distributions of these two species were accurately recorded as part of survey work undertaken during 2009 at two sites within Glen Creran: Glasdrum Wood National Nature Reserve and Creagan using a global positioning system (GPS) device. This survey showed that the pearl-bordered fritillary was largely confined to higher altitudes from 150-350 m whereas the chequered skipper was widely distributed occurring in abundance at both sea level and up to an altitude of 350 m.

A new method of recording habitat characteristics at a butterfly site was devised and this was used to compare the incidence of nectar plants and woodland regeneration between the two sites and between different types of woodland glade. These measurements were made within a 10 m radius of each chequered skipper recorded with a GPS device. Comparison of butterfly distribution data with the habitat characteristics data using a Geographical Information System (GIS) showed that higher numbers of chequered skippers and pearl-bordered fritillaries were found in glade types where their preferred nectar plants were more common. Differences in nectar plant incidence between glade types were found. Differences in woodland regeneration between glade types and between the two sites were found which suggests that this method may be used to assess the condition of woodland glades at sites where these UK BAP species occur.

INTRODUCTION

The chequered skipper, *Carterocephalus palaemon* and the pearl-bordered fritillary, *Boloria euphrosyne* are woodland butterflies which are known to be adversely affected by woodland regeneration (Ravenscroft & Warren, 1996; Barnett & Warren, 1995).

In the UK, the chequered skipper from 1995-2004 was known from just 31 10 km squares in western Scotland from around Lochs Eil and Sheil in Lochaber in the north to Loch Etive in Argyll in the south (Asher *et al.*, 2001; Fox *et al.*, 2006). It formerly occurred in sites in the English Midlands but became extinct in 1976. Decreased traditional management in woodlands, particularly coppicing, is considered to be the main factor for these changes in distribution (Ravenscroft & Warren, 1996).

The pearl-bordered fritillary is in rapid decline at the UK level with the population trend from 1970 to 2004 down by 66% and the comparative figure for Scotland also shows a smaller but still alarming decline of 33% (Fox *et al.*, 2006). Changes in woodland management including the cessation of coppicing which used to provide a succession of new sunny glades within deciduous woodlands, and the maturation of commercial conifer plantations have been the major causes of these declines (Barnett & Warren, 1995). The pearl-bordered fritillary also uses woodland edge habitat such as along wayleaves (cleared areas under pylon lines) but these populations are at low density and may not be viable in the longer term.

To halt the serious decline of pearl-bordered fritillary and to ensure that chequered skipper colonies in Scotland are not lost to woodland regeneration, the traditional woodland management practices which have been lost (mainly coppicing), need to be replaced with a modern equivalent. The South East Woodlands project run by Butterfly Conservation is advising landowners in south-east England how woodlands can be managed to maintain open glades for butterflies and other wildlife. In Scotland, the Controlled Livestock Grazing of Woodland grant was introduced in 2010 as part of the Scottish Rural Development Programme and aims to support landowners who want to maintain or re-introduce traditional land management methods, by using cattle and other livestock to graze woodlands in a sensitive way that enhances their biodiversity. This grant should help conserve these two Priority butterfly species and other wildlife such as moths, dragonflies, black grouse and lichens.

A development which would be helpful in identifying sites which require such woodland management is an objective method to assess whether or not a butterfly site is being adversely affected by woodland regeneration. This paper presents such a method and demonstrates that it is effective in identifying a site in which glades are being lost to woodland regeneration.

METHODS

Fieldwork took place at two sites in Glen Creran (15 miles from Oban): at Glasdrum Wood National Nature Reserve (NN0045) owned by Scottish Natural Heritage; and at Creagan (NM9845) which is privately owned land just to the west of Glasdrum (Fig. 1). Both Glasdrum and Creagan are steep south-facing hillsides with mature deciduous woodland on the lower slopes and open hillside higher up although Creagan is less wooded overall than Glasdrum.

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Some limited survey work on butterfly distribution was carried out by AJM in May 2008 (data not presented). In 2009, AJM did more detailed butterfly survey work during which additional data on nectar plant and woodland scrub incidence were also recorded. This paper reports on this 2009 work

Butterfly distribution

The distributions of chequered skipper and pearl-bordered fritillary were recorded with a Global Positioning System (GPS) device. The model used was a Garmin GPSMAP 60Cx (approx cost £200) which is similar in size to a mobile phone and which has the capability to download both track and waymark data to a computer. The waymark facility was used to record the position of butterflies and a waymark is recorded by pressing the "Mark" button twice. The track is recorded automatically and provides a measure of the area surveyed. The Geographical Information System (GIS) software, ArcGIS 9.2 was used to plot tracks and waymarks from the GPS data onto 1:10000 Ordinance Survey map tiles.

Six visits during sunny weather were made to each of Glasdrum and Creagan between 10 May and 1 June 2009 during the flight period of chequered skipper and pearl-bordered fritillary. While the first few survey dates were early in the flight periods when few butterflies were on the wing, the later dates were during the flight period peaks. Glasdrum was visited on 10, 12, 21, 22, 30 May and 1 June 2009. Creagan was visited on 11, 13, 14, 20, 29 and 31 May 2009.

In the case of the pearl-bordered fritillary, the presence of the similar small pearl-bordered fritillary, *Boloria selene* from 29 May to 1 June made recording pearl-bordered fritillary more difficult. On these dates, pearl-bordered fritillary was only recorded when a close view of the underwing enabled a confident identification which may have under-estimated numbers of this species.

The tracks walked were designed to survey large areas of Glasdrum and Creagan during six days at each site but were mostly in open areas where butterflies would be more likely to be encountered. However, some enclosed wooded areas were included at both sites and the presence of steep escarpments meant not all areas were accessible.

Incidence of nectar plants and woodland scrub

For survey dates from the 20 May to 1 June, the survey methodology was expanded to record the presence/absence of nectar plants and woodland scrub because initial survey work suggested that there might be strong correlations between butterfly distribution and the distribution of nectar plants. And an objective method of assessing woodland scrub regeneration is better than a crude visual judgement.

The presence/absence of nectar plants and woodland scrub were recorded within a 10 m radius of each chequered skipper recorded with a GPS device. A 10 m radius threshold was selected as it was practical limit which should only take a minute or so to assess at each observation point and also for woodland regeneration, scrub within a 10 m radius of a butterfly observation is indicative of a high level of woodland regeneration.

The plant species surveyed were marsh thistle, *Cirsium palustre* which is a preferred nectar plant of chequered skipper, bluebell, *Hyacinthoides non-scripta* which is a preferred nectar plant of pearl-bordered fritillary and bugle, *Ajuga reptans* which is a preferred nectar plant of both species (Ravenscroft & Warren, 1996; Barnett & Warren, 1995). Ragged robin, *Lychnis flos-cuculi* and heath-spotted orchid, *Dactylorhiza maculate* have also been suggested as nectar plants of chequered skipper (Ravenscroft, 1996) and so they and tormentil, *Potentilla erecta* - an abundant flowering plant at both Glasdrum and Creagan – were also assessed.

Two types and two levels of woodland scrub regeneration were assessed. Birch (*Betula* spp.) scrub was found to be the dominant scrub type during earlier survey visits but there was also some hazel, *Corylus avellana* and alder, *Alnus glutinus* scrub which were grouped together in a second scrub type, hazel/alder. It was also considered appropriate to distinguish between short scrub (less than 2 m tall) and tall scrub (over 2 m tall) because although some birch scrub is considered characteristic of chequered skipper habitat (Ravenscroft & Warren, 1996), scrub over 2 m tall is indicative of developing birch woodland which would cause loss of butterfly habitat in the longer term. The higher level of over 2 m tall was deemed to apply when one or more birch plants over 2 m tall were present within the 10 m radius.

Bog myrtle, *Myrica gale* is also considered characteristic of chequered skipper habitat (Ravenscroft & Warren, 1996) and its presence/absence was also recorded within a 10 m radius of a chequered skipper observation.

To compare the incidence of nectar plants and woodland scrub regeneration in different sizes of woodland glade, each chequered skipper observation where the 10 m radius vegetation assessments were done was allocated to one of four glade types: small woodland glades (width < 25 m); large woodland glades (width > 25 m); wayleaves; or open hillside.

Woodland rides and wayleaves with a minimum width of 25 m have been identified as being required for chequered skipper as warm sunny habitat is essential (Ravenscroft, 1994).

Habitat Maps

The data on the distribution of butterflies, nectar plants and woodland scrub regeneration were then used to construct habitat maps using GIS for both pearl-bordered fritillary and chequered skipper at each of Glasdrum and Creagan showing areas with moderate and high quality habitat.

RESULTS

Butterfly Distribution

The distributions of pearl-bordered fritillary and chequered skipper at Glasdrum using data from all six survey visits are shown in Fig. 2. The distribution of the 85 pearl-bordered fritillaries recorded within the site was much more limited being mostly confined to higher altitudes between 300 and 350 m above the main treeline. However, some pearl-bordered fritillaries were found on the northern edge of a large glade at the eastern side of Glasdrum at altitudes of circa 250 m and also a few along the wayleave close to sea-level. By contrast, the 213 chequered skipper were widely distributed.

The distributions at Creagan (Fig. 3) were fairly similar although the 97 pearl-bordered fritillaries were more widespread. They were most abundant in the open areas on the middle and upper slopes at altitudes between 150 and 300 m with a few along the wayleave near sea-level while the 124 chequered skippers were more widely distributed.

The large gaps not surveyed in Figs. 2 and 3 were mostly enclosed woodland where few butterflies would be expected to be found. The tracks with no butterfly observations on the lower slopes mostly relate to areas under enclosed tree canopy.

Incidence of nectar plants and woodland scrub

Fig. 4 shows the distribution of glade types at Glasdrum determined from a total of 203 chequered skipper observations recorded from 21 May to 1 June: 35 wayleave; 30 small glade; 57 large glade; and 81 open hillside. Fig. 5 shows the distribution of glade types at Creagan determined from a total of 108 chequered skipper observations recorded from 20 to 31 May: 9 wayleave; 21 small glade; 29 large glade; and 49 open hillside.

Table 1 compares the percentages of chequered skipper observations recorded between 20 May and 1 June with each nectar plant species for each glade type at each of Glasdrum and Creagan. Ragged robin is not included as none was found at either Glasdrum or Creagan. Chi-squared contingency tables (Table 2) were used to test for differences in the incidence of nectar plants between glade types at each of Glasdrum and Creagan.

Bugle (Table 1) was most abundant on open hillside with this species present in 62% and 41% of this glade type at Glasdrum and Creagan respectively. It was present in moderate levels of around 15% and 40% of small and large woodland glades respectively. Bugle was least common along wayleaves with 10% incidence at Glasdrum and it was not recorded along the Creagan wayleave. Chi-squared tests (Table 2) showed that bugle was significantly more common in the large glade and open hillside glade types at Glasdrum but differences were less at Creagan.

Marsh thistle (Table 1) had a different distribution to bugle with it being most common (89% incidence) along the Creagan wayleave although the second highest incidence was on open hillside at Glasdrum (67% incidence). It was less common (< 30%) in the small and large woodland glade types except for a 40% incidence in large glades at Glasdrum. Marsh thistle was significantly more common on open hillside at Glasdrum than in the other three glade types while at Creagan, it was significantly more common along the wayleave (Table 2).

Bluebell (Table 1) was least common on open hillside with less than 30% incidence at both sites while its abundance was higher in the three other glade types except for small glades at Creagan. This difference was only significant at Glasdrum (Table 2). And bluebell was significantly more abundant at Glasdrum than at Creagan ($t = 5.25$, df 3, $P < 0.05$).

Tormentil was very common in all four glade types at both sites (Table 1) ranging from 72% incidence in large glades at Glasdrum to 100% incidence along the wayleave at Creagan. As a result, there were only two weakly significant differences between glade types (Table 2).

Heath-spotted orchid (Table 1) was uncommon with a maximum incidence of only 17% along the wayleave at Glasdrum which resulted in two significant differences between glade types at this site. There were no significant differences between glade types at Creagan (Table 2).

Table 3 compares the percentages of chequered skipper observations recorded between 20 May and 1 June with each woodland scrub type for each glade type at each of Glasdrum and Creagan. Chi-squared contingency tables (Table 4) were used to test for differences in the incidence of woodland scrub between glade types at each of Glasdrum and Creagan.

Short birch scrub (Table 3) had its highest incidence along the wayleave at Glasdrum (80%) followed by on open hillside at Creagan (67%). Overall, it was least common in large woodland glades although the incidence of 11% along the Creagan wayleave was also low. While incidence of short birch scrub was similar

at Glasdrum and Creagan ($t = 0.09$, df 3 , N.S), there were significant differences between glade types at both sites (Table 4).

Tall birch scrub (Table 3) was much more common in all four glade types at Creagan than at Glasdrum ($t = 3.75$, df 3, $P <0.05$). This contrast was greatest for large glades where incidence was 72% at Creagan and just 2% at Glasdrum. There were significant differences between glade types for tall birch scrub at both sites (Table 4).

The incidence of short hazel/alder scrub (Table 3) was similar at the two sites ($t = 2.12$, df 3, N. S.) and was highest along wayleaves with incidences of 66% and 44% for Glasdrum and Creagan respectively. The percentages were fairly similar at the two sites for the other three glade types which had progressively less scrub in the following order: small glade; large glade; and open hillside. There were three significant differences between glade types for short hazel/alder scrub at Glasdrum but none at Creagan (Table 4).

Tall hazel/alder scrub (Table 3) like tall birch scrub was more common at Creagan than at Glasdrum ($t = 4.39$, df 3, $P < 0.05$) and was less common than short hazel/alder scrub in all four glade types. Like short hazel/alder scrub, its incidence was highest along wayleaves with incidences of 29% and 33% for Glasdrum and Creagan respectively. There was also progressively less scrub in the other three glade types in the same order: small glade; large glade; and open hillside. There were significant differences between glade types for tall hazel/alder scrub at both sites (Table 4).

Bog myrtle (Table 3) was also more common at Creagan than Glasdrum ($t = 11.27$, df 3, $P < 0.001$) being abundant in all four glade types at Creagan (69-89%) while it was absent from large glades and only found in 3% of small glades at Glasdrum. This resulted in four significant differences between glade types at Glasdrum but none at Creagan (Table 4).

Habitat Maps

Habitat maps were constructed for both Glasdrum and Creagan and these identified areas of high and moderate quality habitat for chequered skipper and pearl-bordered fritillary. The two maps for Creagan are presented as they are less complex.

Fig. 6 shows the habitat map for chequered skipper at Creagan in which three areas of high quality habitat and two areas of moderate quality habitat have been identified. The distribution of all the 124 chequered skipper recorded during the survey in 2009 is also plotted. The high quality areas are open hillside where both its preferred nectar plants, bugle and marsh thistle (Table 1) were relatively abundant, the wayleave where marsh thistle had its highest abundance (Table 1) and the large glade in the eastern side of Creagan which had abundant bugle in places. The moderate quality areas are the woodland areas in Fig. 6 in which there are some small and large woodland glades (Fig. 5). Tall birch scrub was present in 48% and 72% of small and large glades (Table 3) respectively at Creagan indicating that these were filling in and becoming less favourable for chequered skipper. A moderate quality classification for small and large woodland glades at Creagan is also appropriate because marsh thistle was relatively scarce in these two glade types as was bugle in small glades (Table 1).

Fig. 7 shows the habitat map for pearl-bordered fritillary at Creagan in which two areas of high quality habitat and two areas of moderate quality habitat have been identified. The distribution of all the 97 pearl-bordered fritillary recorded in 2009 is also plotted. The high quality areas are open hillside and a large glade in the east of Creagan where its preferred nectar plant, bugle (Table 1) was common. Neither tall birch scrub nor tall hazel/alder scrub (Table 3) was an issue on open hillside at Creagan although tall birch scrub was present in parts of the large glade. The moderate quality habitat areas in Fig. 7 relate to the wayleave where only a few pearl-bordered fritillary were seen and where bugle was absent (Table 1) and the area labelled developing birch woodland where there was abundant tall birch scrub threatening existing habitat in the long term although the butterfly was quite common here.

DISCUSSION

This paper has shown two useful applications of a GPS device in butterfly monitoring. First, it demonstrates that recording the distribution of butterflies at a site with a GPS device can identify areas with higher numbers which are likely to correspond with areas of higher quality habitat. The greater precision of butterfly records obtained with a GPS device (ten figure grid references) results in a more accurate distribution map than one based on manually recorded six-figure grid references and the latter method is impractical where large numbers of butterflies are on the wing as was the case in this study. Also, the track facility shows the areas surveyed and this provides information on where butterflies are not present.

Second, it shows how habitat characteristics can be measured within a 10 m radius of a butterfly observation recorded with a GPS device. Data on habitat characteristics are useful information for butterfly species termed habitat specialists by Butterfly Conservation (Asher *et al.*, 2001). These species require key plant species and often vegetation of a particular height, aspect and possibly slope. Such habitat tends to only occur in fragments of semi-natural habitat which are rare in the modern landscape. It is useful to have an objective method of measuring the habitat of these species to provide data on the abundance of larval foodplants and adult nectar plants as such data may explain why these species have limited distributions. This study did not record the incidence of larval foodplants of chequered skipper or pearl-bordered fritillary but the method can be adapted to include them.

The incidence of the neetar plants shows that high numbers of ehequered skipper at Creagan along wayleaves and on open hillside (Fig. 6) are associated with a high abundance of marsh thistle (Table 1) while the high numbers of pearl-bordered fritillary on open hillside (Fig. 7) at Creagan are associated with high levels of bugle (Table 1). Ockinger *et al.* (2006) have shown that species richness of butterflies and vascular plants decreases with increased cover of trees and shrubs and this study shows this to be true for ehequered skipper, pearl-bordered fritillary and their nectar plants which were only found in open areas of Glen Creran Woods which included wayleaves, small and large woodland glades and open hillside. The traeks with no butterfly observations on the lower slopes in Figs. 2 and 3 mostly relate to areas under enclosed tree eanopy.

The nectar plant, bluebell (Table 1) was least common on open hillside and was more abundant at Glasdrum than at Creagan. As bluebell is a woodland species, it is expeeted that it would be less common on open hillside and the greater abundance at Glasdrum reflects the higher levels of mature woodland present.

Both species action plans (Ravenscroft & Warren, 1996; Barnett & Warren, 1995) identify the need for appropriate woodland management to maintain sufficient open areas for these two UK BAP species. Therefore, there is a need for an objective method of measuring the extent of woodland regeneration at sites where these species occur to identify whether or not woodland management is maintaining adequate open areas. The method of assessing woodland regeneration used in this paper revealed significantly higher levels of tall birch and hazel/alder scrub at Creagan than at Glasdrum while levels of short bireh and hazel/alder scrub were similar (Table 3). This shows that it is important to distinguish between short scrub which is a normal component of any woodland glade and tall scrub which is characteristie of developing woodland which would inevitably mean the glade will fill in unless the woodland regeneration is controlled.

The significantly higher levels of tall birch and hazel/alder scrub at Creagan are probably due to different management. In recent decades, management at Glen Creran Woods has been to encourage woodland regeneration by excluding livestock and removing conifers whilst maintaining some open areas for butterflies. At Creagan, roe deer, *Capreolus capreolus* and red deer, *Cervus elaphus* numbers were also controlled and this factor probably accounts for the mueh higher levels of tall birch and hazel/alder scrub here (Table 3). Deer grazing is recognized as an important factor in maintaining woodland glades in a favourable condition for these two UK BAP butterflies (Ravenscroft & Warren, 1996; Barnett & Warren, 1995). Balancing woodland regeneration and the management of woodland clearings for butterflies at Glen Creran is a challenge for woodland managers.

The method of reeording habitat characteristics used in this study can be adapted for other habitat specialist butterfly species and could include other habitat charaeteristics such as aspect, slope or percentage bracken, *Pteridium aquilinum* cover as well as incidence of larval foodplants. Although the presence of a habitat specialist butterfly such as chequered skipper in an area is not random (suitable habitat is required), the point at which a walking observer sees a butterfly whieh is itself flying around in an erratic manner is random Therefore the points at which habitat characteristics were recorded were random selections within the habitat area. The fact that measurements were taken at many different points provides a much more robust assessment of the site than an approach based on a single point or a single estimate based on a walk throughout the whole site. Also, measuring the presence/absence of nectar plants and woodland scrub regeneration were more objective methods than scoring systems. The designation of the four glade types used in this study was appropriate for these two woodland butterflies but this is an optional elaboration of the methodology.

If habitat characteristics are recorded at a number of different sites where chequered skipper and/or pearl-bordered fritillary occur, it will be possible to determine what level of abundance of larval foodplants and nectar plants is required by these woodland butterflies and what level of woodland regeneration has no detrimental effect. Using such a database, it will be possible to objectively determine whether or not woodland regeneration is adversely affecting a butterfly site. This provides a more robust habitat/species assessment than a walk through a site in which a crude visual judgement is made.

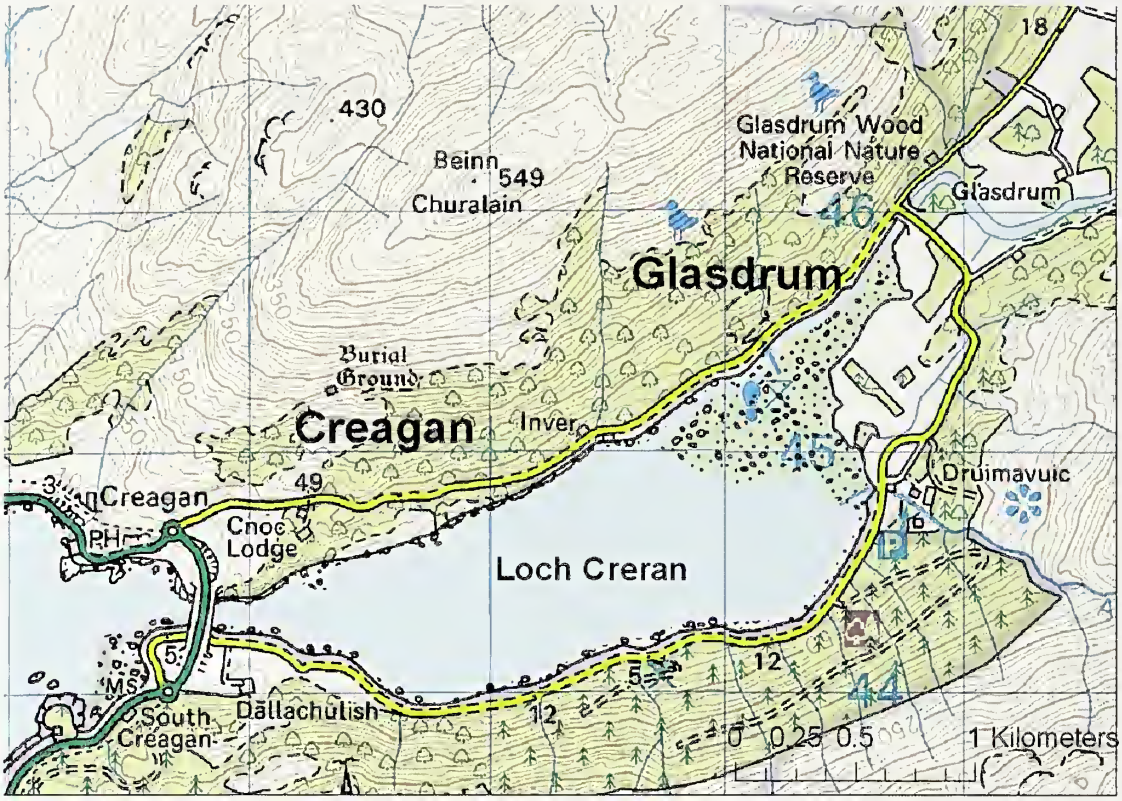

Fig. 1. Location of Glasdrum and Creagan on the north side of Loch Creran, Argyll. © Crown Copyright and database right 2010. All rights reserved. Ordnance Survey Licence number 100017908.

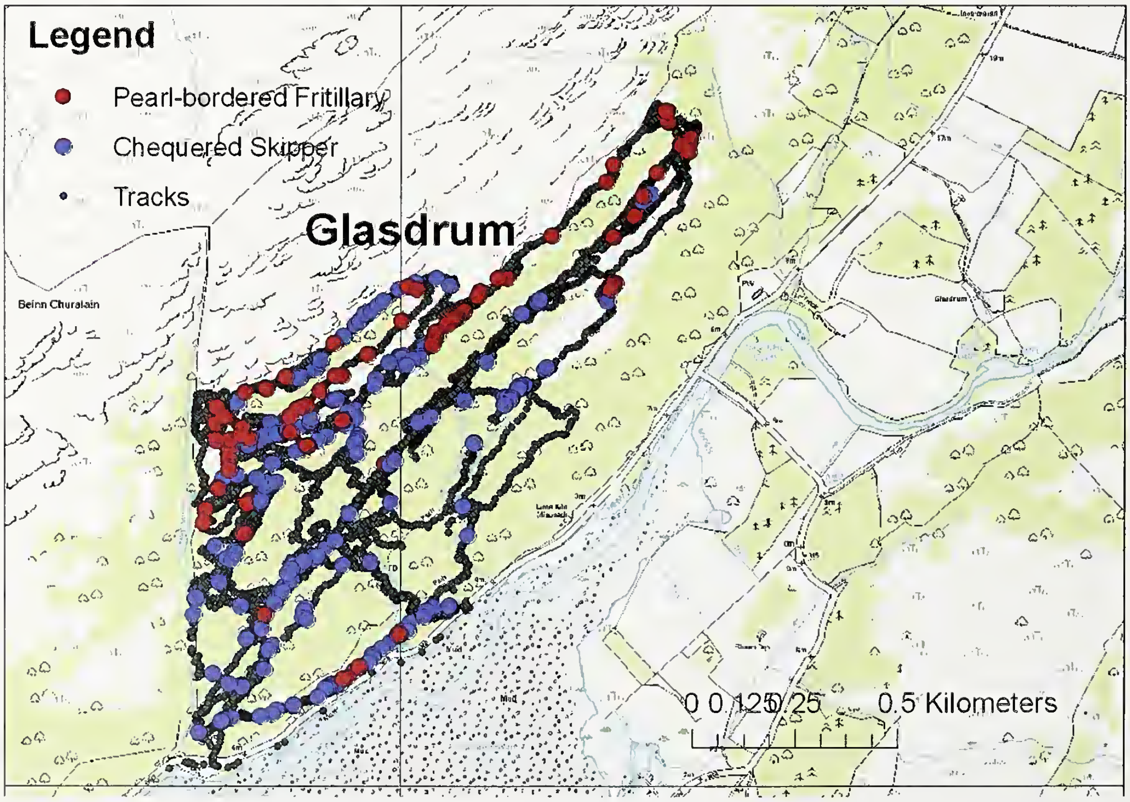

Fig. 2. Distribution of pearl-bordered fritillary and chequered skipper at Glasdrum during six visits in 2009 and the tracks walked by the recorder. © Crown Copyright and database right 2010. All rights reserved. Ordnance Survey Licence number 100017908.

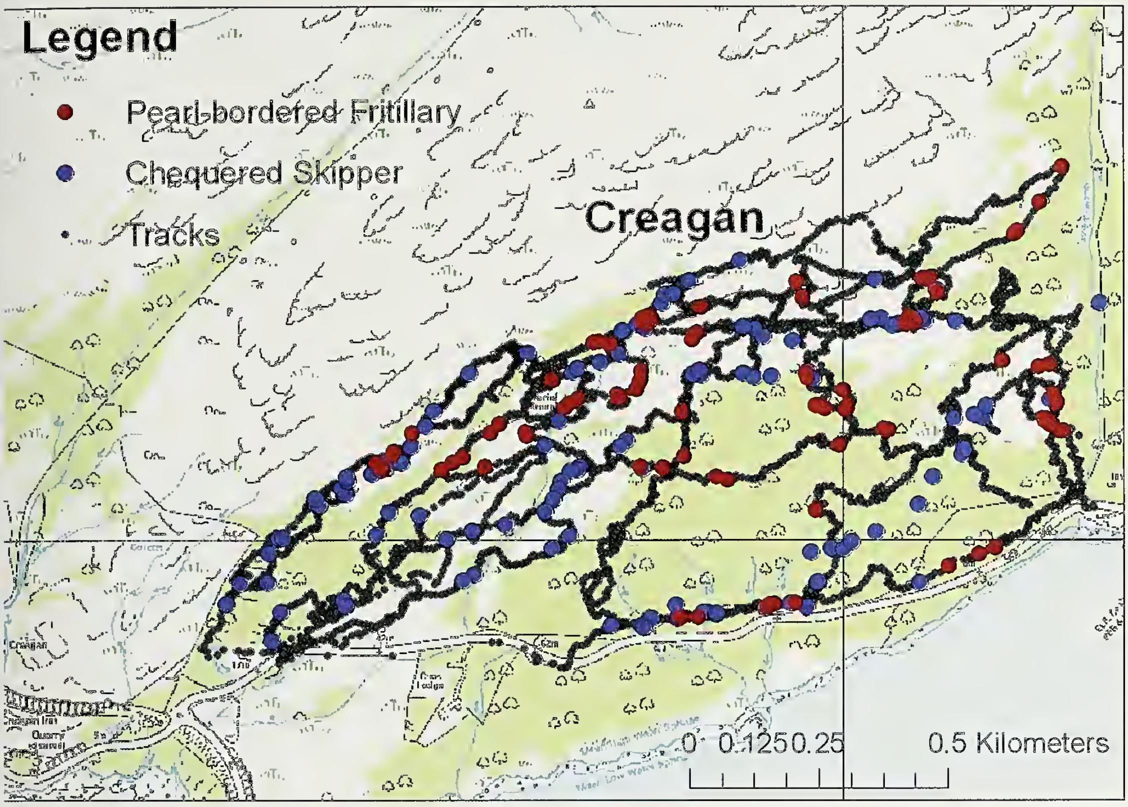

Fig. 3. Distribution of pearl-bordered fritillary and chequered skipper at Creagan during six visits in 2009 and the tracks walked by the recorder. © Crown Copyright and database right 2010. All rights reserved. Ordnance Survey Licence number 100017908.

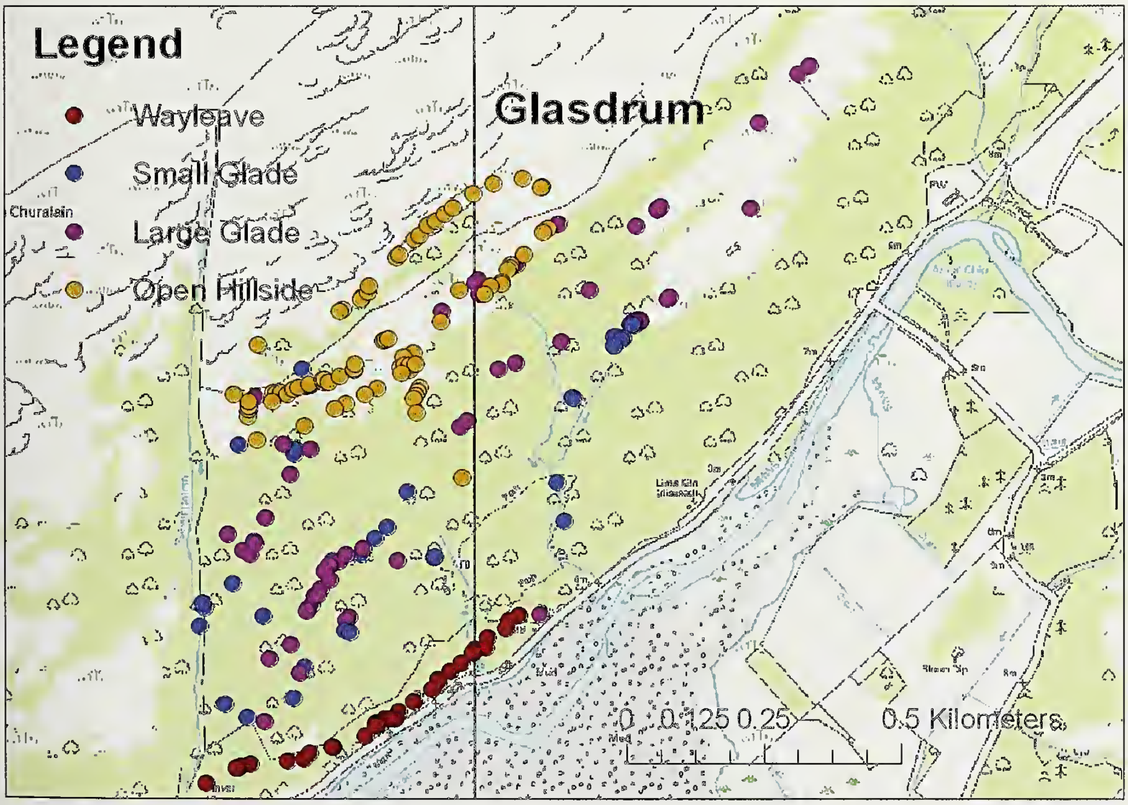

Fig. 4. Distribution of glade types at Glasdrum relating to 203 chequered skipper observations. © Crown Copyright and database right 2010. All rights reserved. Ordnance Survey Licence number 100017908.

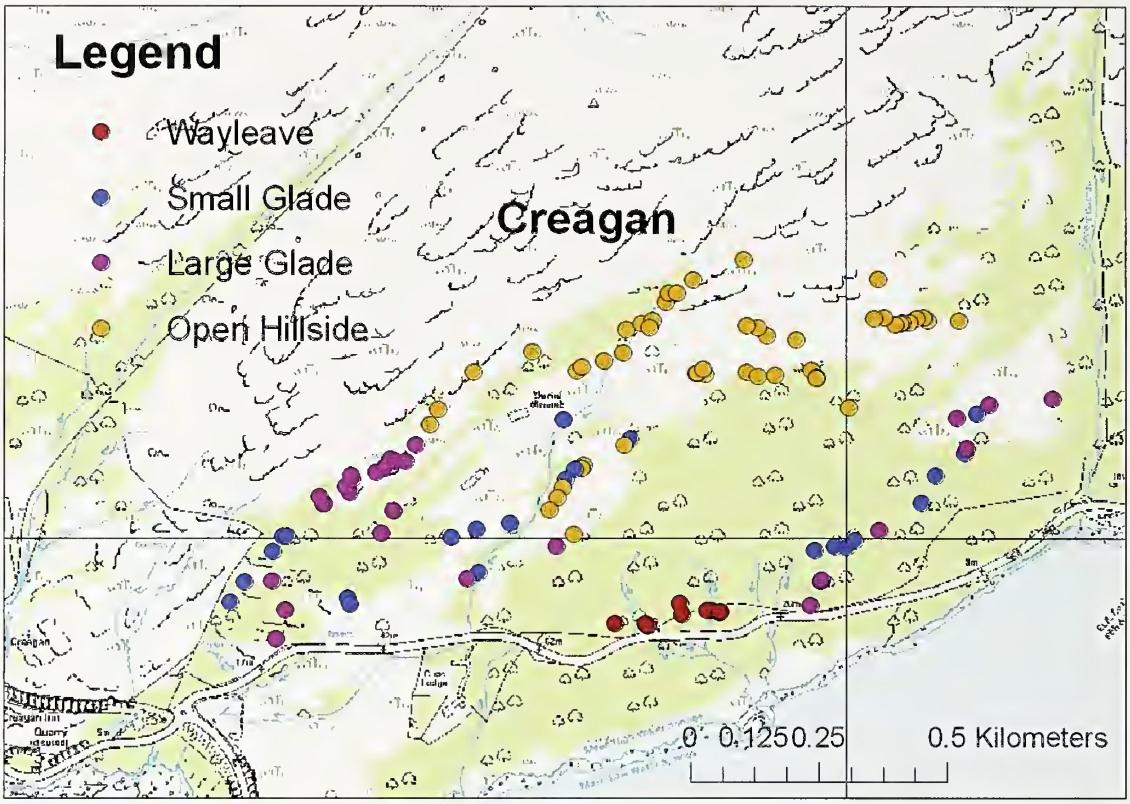

Fig. 5. Distribution of glade types at Creagan relating to 108 chequered skipper observations.

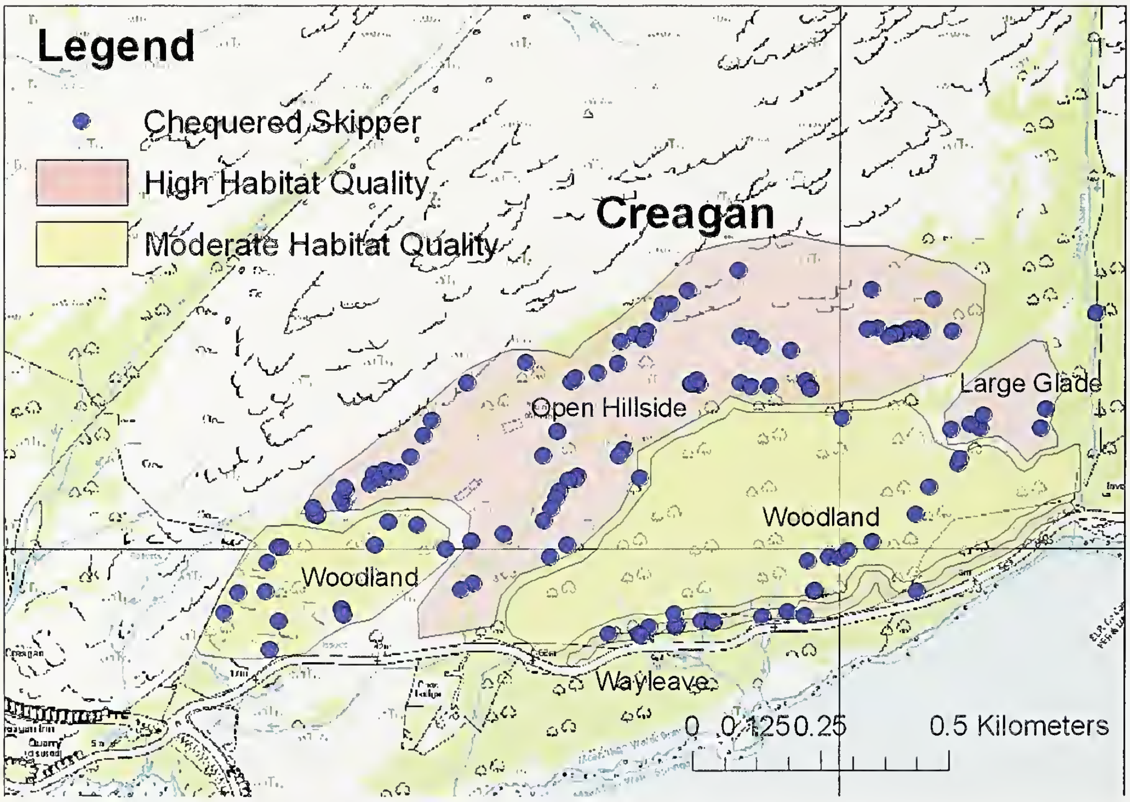

Fig. 6. Chequered skipper habitat map for Creagan constructed using the data presented in Fig. 3 and Tables 1 and 3.

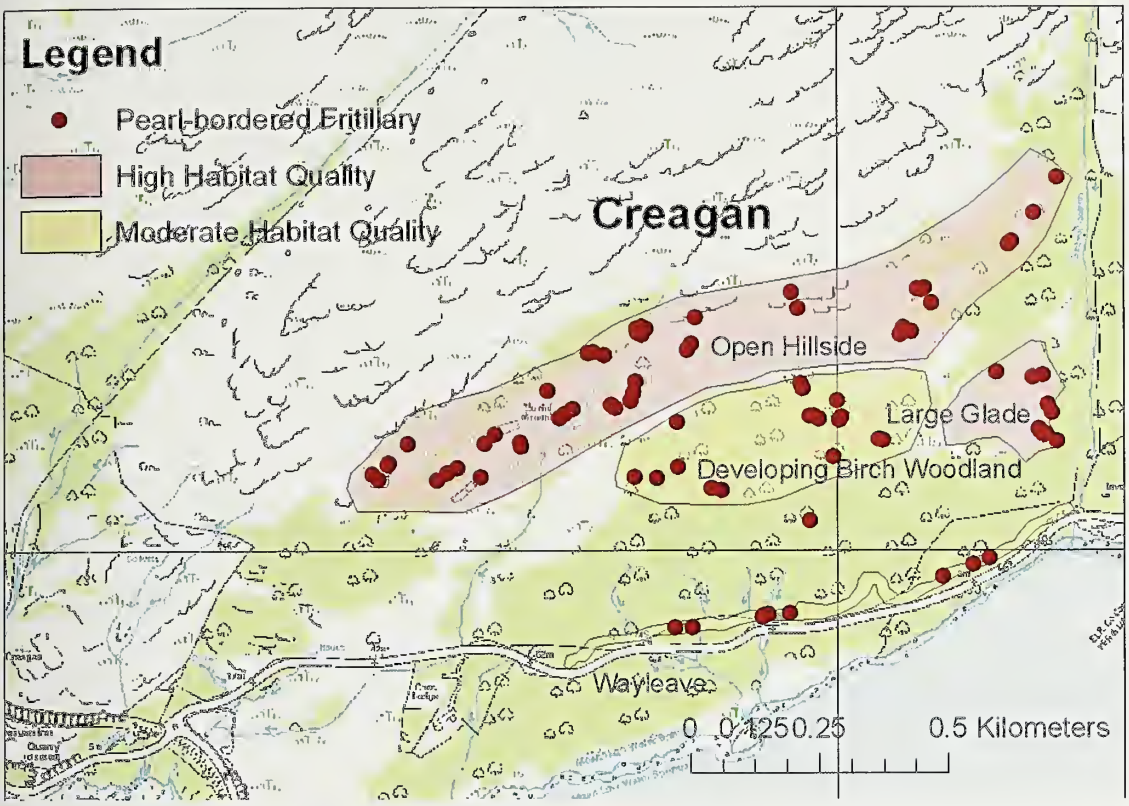

Fig. 7. Pearl-bordered fritillary habitat map for Creagan constructed using the data presented in Fig. 3 and Tables 1 and 3.

	Percentage of chequered skipper observations with nectar plant									
	Glas/Creag		Glas/Creag		Glas/Creag		Glas/Creag		Glas/Creag	
Glade Type	**Bug**		**Mar**		**Blu**		**Tor**		**Hea**	
Wayleave	11	0	46	89	57	33	91	100	17	11
Small Glade	20	14	23	19	53	24	83	81	3	0
Large Glade	44	38	40	14	65	31	72	93	0	14
Open Hillside	62	41	67	45	26	14	89	94	8	4

Glas – Glasdrum Creag – Creagan

Bug – Bugle Mar – Marsh Thistle Blu – Bluebell Tor – Tormentil Hea – Heath Spotted Orchid.

Table 1. Comparison of the incidence of nectar plants (percentages) within a 10 m radius of a chequered skipper observation in each glade type at Glasdrum and Creagan.

Glasdrum	Chi-squared values and significance				
Glades being tested	Bugle	Marsh Thistle	Bluebell	Tormentil	Heath Spotted Orchid
Wayleave vs Small Glade	0.91	3.54	0.09	0.98	0.434†
Wayleave vs Large Glade	10.57**	0.26	0.56	5.03*	10.45***
Wayleave vs Open Hillside	24.85***	4.85*	10.42**	0.17	2.5
Small Glade vs Large Glade	4.88*	2.52	1.11	1.4	1.92
Large Glade vs Open Hillside	4.31*	9.97**	20.87***	6.49*	4.41*
Small Glade vs Open Hillside	15.25***	17.23***	7.4**	0.61	0.61

Creagan	Chi-squared values and significance				
Glades being tested	Bugle	Marsh Thistle	Bluebell	Tormentil	Heath Spotted Orchid
Wayleave vs Small Glade	1.43†	12.8***†	0.29†	1.98†	2.41†
Wayleave vs Large Glade	4.8*†	17.93***†	0.02†	0.66†	0.04†
Wayleave vs Open Hillside	5.61*†	5.89*†	1.93†	0.58†	0.77†
Small Glade vs Large Glade	3.38	0.25†	0.32	1.7†	3.15†
Large Glade vs Open Hillside	0.06	7.93**	3.13	0.02†	2.42†
Small Glade vs Open Hillside	4.69*	4.21*	0.94†	2.73†	0.88†

† some expected values less than 5 * P < 0.05 ** P < 0.01 *** P < 0.001

Table 2. Results of chi-squared tests comparing differences in the incidence of the nectar plants between glade types at Glasdrum and Creagan.

	Percentage of chequered skipper observations with woodland scrub									
	Glas/Creag		Glas/Creag		Glas/Creag		Glas/Creag		Glas/Creag	
Glade Type	Short Birch		Tall Birch		Short Haz/Ald		Tall Haz/Ald		Bog Myrtle	
Wayleave	80	11	17	89	66	44	29	33	29	89
Small Glade	30	38	17	48	40	24	13	19	3	76
Large Glade	7	24	2	72	32	24	4	7	0	69
Open Hillside	31	67	0	22	20	22	0	2	30	78

Glas – Glasdrum Creag – Creagan

Short - < 2 m tall Tall - > 2 m tall Haz/Ald – Halzel or Alder

Table 3. Comparison of the incidence of woodland scrub (percentages) within a 10 m radius of a chequered skipper observation in each glade type at Glasdrum and Creagan.

Glasdrum	Chi-squared values and significance				
Glades being tested	Short Birch	Tall Birch	Short Haz/Ald	Tall Haz/Ald	Bog Myrtle
Wayleave vs Small Glade	16.47***	0	4.3*	2.22	7.32**
Wayleave vs Large Glade	50.92***	7.3**†	2.14	12.01***†	18.27***†
Wayleave vs Open Hillside	23.78***	14.64***†	18.79***	25.33***†	0.01
Small Glade vs Large Glade	8.17*†	6.81**†	0.5	2.95†	1.92†
Large Glade vs Open Hillside	11.46***	1.43†	7.69**	2.88†	20.44***
Small Glade vs Open Hillside	0.01	14.14***†	3.21	11.2***†	8.68**

Creagan	Chi-squared values and significance				
Glades being tested	Short Birch	Tall Birch	Short Haz/Ald	Tall Haz/Ald	Bog Myrtle
Wayleave vs Small Glade	2.18†	4.47*†	1.28†	0.72†	0.63†
Wayleave vs Large Glade	0.7†	1.03†	1.38†	4.2*†	1.41†
Wayleave vs Open Hillside	9.91**†	15.24***†	1.92†	11.6***†	0.6†
Small Glade vs Large Glade	1.13	3.18	0	1.7†	0.32
Large Glade vs Open Hillside	13.61***	18.8***	0.03	1.16†	0.7
Small Glade vs Open Hillside	5.18*	4.43*	0.02†	6.41*†	0.02†

Haz/Ald Hazel/Alder scrub
† some expected values less than 5 * $P < 0.05$ ** $P < 0.01$ *** $P < 0.001$

Table 4. Results of chi-squared tests comparing differences in the incidence of woodland scrub between glade types at Glasdrum and Creagan.

ACKNOWLEDGEMENTS

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The history and current status of the orange ladybird *Halyzia sedecimguttata* (Linnaeus, 1758) in the Clyde area in the UK context (Coleoptera: Coccinellidae)

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ABSTRACT

Records of orange ladybird *Halyzia sedecimguttata* from the Clyde area in the past ten years are reviewed in the context of earlier records from the area. This species appears now to be much more common and widespread, and the increase appears to be linked to a new association with *Acer* spp., particularly sycamore. These findings are discussed in the light of a similar increase which appears to have occurred in England some years earlier.

INTRODUCTION

Recent reports in The Glasgow Naturalist of sightings of the orange ladybird in the West End of Glasgow (Grist, 2002) and in Dumbarton (Futter & Futter, 2001) attest to the apparent comparative rarity of this species in the Clyde area (and Scotland generally) in previous years. The former is apparently the first record within the City of Glasgow, and the latter is the first urban record in Dunbartonshire, and one of a very few (at that time) known records in the Greater Glasgow area. Both accounts comment on the previous lack of records for that area, mention an association with sycamore, and Grist wonders if it is becoming more common. However, the subsequent increase in frequency of sightings of this species - notably in and around the author's address in north west Glasgow (not far from Grist's location), and in other parts of Glasgow have prompted this review of recent and historical records as well as field-visits to look for further occurrences. The 'Clyde area' in this account generously includes: North and South Lanarkshire (VC77); Glasgow (various VCs); Renfrew, East Renfrewshire & Inverclyde (VC76); North, South and East Ayrshire (VC75), East and West Dunbartonshire (VC99), Argyll and Bute (VCs 98, 100, 101, 102 & 103); and the western part of Stirling (part of VC86). In this review, details of grid references for the various sightings mentioned are not given, as in the 'historical' records the locations are merely indicative, and should be interpreted as 'in the general area' of the location specified, though almost certainly in a birch woodland. And whereas the more recent records may have more or less accurate grid references, even this is often a site centroid (for a park etc). Details of any of these records can be found, and downloaded if necessary, from the NBN Gateway, the 'Clyde' records also can be supplied on request from Glasgow Museums BRC: biological.records@glasgowlife.org.uk

In the account below, the following acronyms are used:
BRC: Biological Record Centre
CP: Country Park
LNR: Local Nature Reserve
NBN: National Biodiversity Network
NMS: National Museum of Scotland
SSSI: Site of Special Scientific Interest
- and the scientific name of the orange ladybird is abbreviated to *H. 16-guttata*

METHODS

The orange ladybird is a distinctive insect having orange elytra usually with eight irregular white (or off-white) spots on each. However rather darker specimens, perhaps with only fourteen spots clearly visible, can resemble paler specimens of the cream-spot ladybird *Calvia quattuordecimguttata* which is normally a mahogany colour, and generally has fourteen spots.

The easiest way to distinguish them in the field is to check the alignment of the spots: the cream-spot ladybird, generally has a (transverse) row of 6 spots behind the two at the bases of the elytra; in the orange ladybird, the spots can only be aligned in transverse arcs, and none of these includes more than 4 spots. In the event that these characteristics do not give a clear verdict, microscopic examination of the underside is necessary; see Majerus, M. and Kearns, P. (1989) for details. A cluster of orange ladybirds is illustrated in Fig. 1. Adult and larval orange ladybirds have been recorded by the author on leaves of deciduous trees (*Acer* sp. particularly sycamore, and birch), congregating on tree trunks and posts, and resting on walls and windows. In addition, records of orange ladybird have been gleaned from other local naturalists, from various museum collections in Scotland, from the Scottish biological record centres, from the NBN Gateway, and from literature sources (published and unpublished).

Fig. 1. A cluster of orange ladybirds on a holly-trunk in Tollcross Glen (NS6368 6358), December 16th 2006 (RB Weddle, L Gemmell, G Linstead).

RESULTS

Historical Records

Murray (1853) gives the Scottish locations for *Coccinella sedecimguttata* (as *H. 16-guttata* was then known) as 'Roslin, Cramond, Raehills etc', that is the 'Forth' and 'Solway' areas, though Fowler (1888) lists it as 'rare, on birches' in the Solway, Forth, Tay, Dee and Moray areas. Sharp's Catalogue (Sharp, 1876) adds nothing to Fowler's information. The first record in the Clyde area is apparently at Luss (c. NS3593) on Loch Lomond, recorded in August 1870 by the Rev. JE Somerville (Somerville, 1870); this supplies the only occurrence for this species quoted in the 1901 Handbook (Fergusson, 1901). The analogous 1876 Handbook does not include Coleoptera. A Renfrewshire Catalogue (Anon, 1932) lists nine Coccinellid species, but *16-guttata* is not one of them. This list acknowledges the contributions of Anderson Fergusson, whose earliest record of this species was from Lochgoilhead in September 1915 (the specimen is in the Hunterian Museum collection in Glasgow). Fergusson had been collecting Coleoptera for many years prior to this date. A specimen in the National Museum of Scotland attests to a record made by William Evans in 1892 at Fearnan on Loch Tay, but this is outside the Clyde area. There is however a specimen in the TG Bishop collection (Hunterian Museum) that was taken at Taynuilt, presumably in the latter part of the 19th century; and a further specimen in Glasgow Museums collection taken by John Leslie at Aberfoyle in September 1900. Apart from these, no other 19th century records of the species in the Clyde area have come to light.

Early records from other parts of Scotland are similarly sparse (see Fowler, 1888), suggesting that the species was indeed difficult to find in the 19th century, a time when many dedicated coleopterists were enthusiastically recording, collecting and describing the beetle fauna of most areas of Scotland, apparently giving particular attention to mature broadleaf woodland habitats, which typically support a diverse range of insects, and which, as discussed below, would be the favoured habitat of *H. 16-guttata*. It also seems significant that the prolific collector JJFX King (1858-1926), who worked mainly in the Clyde area and Strathspey, had only one specimen of *H. 16-guttata* in his collection: from Loch Maree area in 1916 (now in the Hunterian Museum). The earliest 20th century record, after Fergusson's at Lochgoilhead, is from Rowardennan by AH May in May 1917 (NMS collection). Fergusson collected another specimen at Pluscarden (near Elgin) in 1938. Thereafter, between the years 1958 and 1994, I have been able to find only seven specimens recorded/collected by Roy and Betty Crowson: from around the southern part of Loch Lomond and at Killiegowan Wood (near Gatehouse of Fleet), the latest being at Balloch Park in 1994 (Crowson, 1997). Crowson would typically underline records of *H. 16-guttata* in his field diary/notebook to indicate its noteworthiness. His records of the species are very few and far between, and the fact that he was in the habit of noting all the species he took indicates that this is a good indication of how often he came across it – and he did much of his collecting in long-established broad-leaf woodlands, the 'traditional' habitat of the species.

The Fergusson and Crowson specimens are in the Hunterian Museum collection, which also contains specimens (from several collectors) from other parts of Scotland, especially the more southern Highland areas. Again, though there well may be further records not yet located, this sample seems to contain significantly few records, and suggests that the distribution of this species was as 'local' for most of the 20th century as it was in the 19th. Fig. 2 illustrates the Scottish records known prior to 1980. A comparison with the records up to 1996 (Fig. 3), shows a significant increase in frequency of observation and spread of distribution. This is undoubtedly mainly due to an increase in recording effort, particularly in the Highland Region, though here, as far as can be ascertained, the records are all from long-established broad-leaf woodlands, and it is not until 1998 that an association with sycamore is noted. The Scottish Invertebrates Records Index (SIRI) includes only one published reference to *H. 16-guttata*: that of Grist (2002).

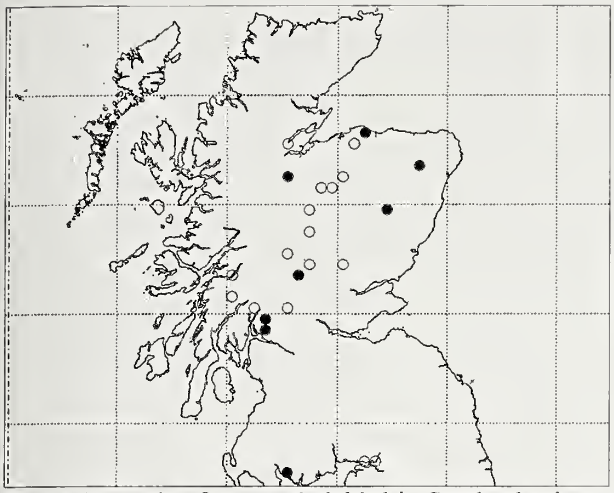

Fig. 2. Records of orange ladybird in Scotland prior to 1980 (pre-1940 records shown as open circles, 100km OS squares). Glasgow Museums BRC.

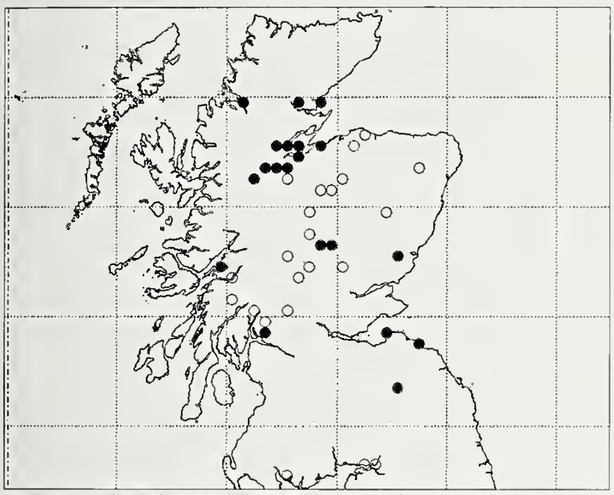

Fig. 3. Records of orange ladybird in Scotland prior to 1996 (pre-1980 records shown as open circles, 100km OS squares). Glasgow Museums BRC and other sources.

Recent records

Since the first urban sightings by Norman Grist in 1999 (Grist, 2002) and Susan and Keith Futter in 2000 (Futter & Futter, 2001), the orange ladybird has frequently been seen in and around Airlie Lane, Hyndland (personal obs.), sometimes resting on windows or walls (there are several mature sycamores in the lane). I have also found it (dead) indoors in Pollokshields, and there have been reports from many of the Glasgow parks, notably Tollcross Park where large numbers can be seen in late autumn or early spring congregating on a holly tree in Tollcross Glen, numbering over 160 on one occasion (G. Linstead, pers. comm.). Similar, though smaller, clusters have been noted on wooden posts in Castle Semple CP (P. Boustead, pers. comm.) and on metal railings in Glasgow Botanic Gardens (P. Thomson, pers. comm.). Other locations where the insect has been seen in the Clyde area during the last 10 years are: Kelvingrove Park, Dawsholm Park LNR, Garscadden Wood, Pollok CP, University of Glasgow campus, Dams to Darnley CP, Hyndland Old Station Park, Gartnavel Hospital area, Garscube Allotments, Glasgow Necropolis, Mugdock CP, Chatelherault CP, Calderglen CP, Plean CP, Gleniffer Braes CP, Dean Castle CP, Culzean CP, Ayr Gorge SSSI, West Kilbride quarry, Isle of Bute, Isle of Arran, and Grianain Forest (Kintyre). *H. 16-guttata* has been recorded on other *Acer* species, particularly the 'ornamental' types (pers. obs.) and on *Cornus* sp. (Majerus, 1995); a pair have been seen mating on a sunny *Cornus* leaf in Hyndland Old Station Park (pers. obs.). It has also been reported in association with moth traps (pers. obs.; N. Gregory, pers. comm.). There are records from in or around both mercury-vapour and tungsten (Rothamsted) light traps; this suggests that the orange ladybird may prefer to fly at night. Other Coccinellidae are rarely found in or around traps; I have found the much more common (in urban environments) two-spot ladybird (*Adalia bipunctata*) and ten-spot ladybird (*Adalia decempuncata*) in the trap only once each. The records mentioned above are mapped, along with records from other sources, in Fig. 4. All the records so far discovered (apart from those from other BRCs) have been added to the Glasgow Museums Biological Record Centre database and will be made available on the NBN Gateway (NBN, 2009) which also shows records from other sources, and is updated several times a year.

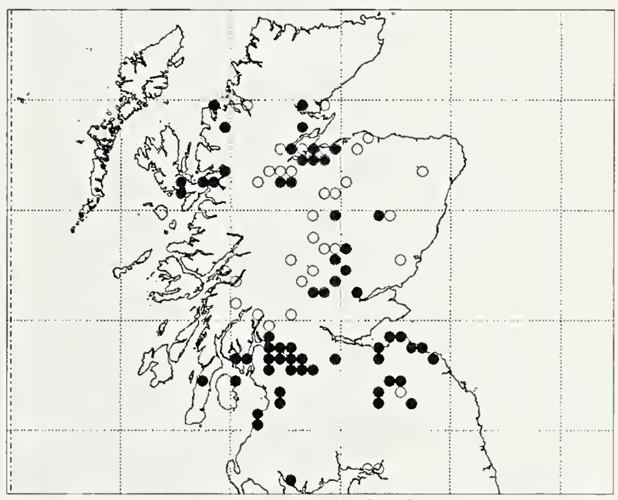

Fig. 4. Records of orange ladybird in Scotland to date (pre-1996 records shown as open circles, 100km OS squares). Glasgow Museums BRC and other sources.

DISCUSSION

Muggleton (1996) begins an account of *H. 16-guttata* by saying that until 'less than 20 years ago' the species was only known from 'the Scottish Highlands and a few scattered sites in southern England', the former presumably referring to the locations listed in Fowler. Even as late as 1989, the status of *H. 16-guttata* was described as 'local and scarce' (Majerus and Kearns, 1989). Muggleton goes on to describe how in England the species appears to have 'undergone an explosive spread in the southern half of England and in Wales' in the decade to 1996. The records listed above suggest that the population in the Clyde area began to follow suit shortly afterwards; and information from BRCs in other parts of Scotland indicate a similar trend (see Figs 2-4). The current distribution of *H. 16-guttata* for the whole of the Britain and Ireland (NBN, 2009) as

shown on the NBN Gateway is reproduced in Fig. 5 to emphasise the current abundance of records of this species in England, though many of the observations from Scotland and the Clyde area in particular (Figs 2-4) were not available on NBN at that date.

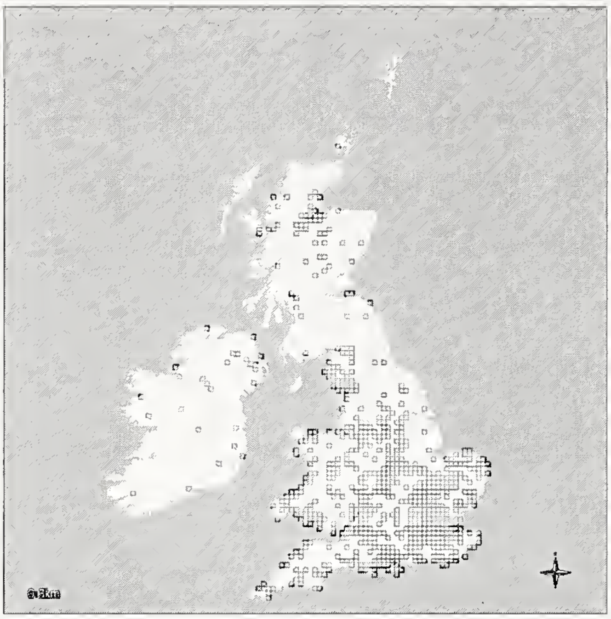

Fig. 5. Distribution of orange ladybird records in the British Isles as shown on the NBN Gateway (2009) prior to the submission of records from Glasgow Museums BRC.

The orange ladybird feeds on mildew typically on leaves of birch (*Betula* sp.) or occasionally ash (*Fraxinus excelsior L.*) (Majerus, 1989). The increase in numbers appears to be associated with a move to sycamore (*Acer pseudoplatanus L.*). Possible factors which may have contributed to this change in habit could include an adaptive change in the ladybird itself Majerus (1995), perhaps associated with a change in the species or quantity of mildew(s) associated with sycamore leaves; the latter could speculatively be associated with the reduction in atmospheric pollution over the last 50 years, and could have supported an increase in the numbers of sycamore aphids producing greater quantities of the honeydew which is the primary substrate of the mildews. The observation that the habit of associating with sycamore seems to have spread gradually northwards supports the idea that migration (of ladybird, aphids or fungus) has played a part, as the air quality changes would have occurred more uniformly across the UK. However it is doubtful whether these effects can be properly investigated retrospectively unless sufficient material (such as specimens of the ladybird, aphids, mildewed sycamore leaves) can be found in collections. On the other hand, Majerus (1995) suggests that the recent increase in frequency of reports of the species was merely a result of more recorders giving attention to sycamore once the association had been publicised. This may well be true in some areas of the UK, but it seems hardly credible that what is now one of the most frequently-reported Coccinellid species could have gone almost completely unnoticed in the Clyde area by the collectors mentioned above. And, though most of the adult insects may well spend most of the summer months relatively high in the tree canopy, they can be seen in significant numbers on tree trunks and posts at a height of 1-2m in the spring and late autumn, and the larvae can be found on the lowest leaves in mid-summer (pers. obs.), so the species is unlikely to have escaped notice for so long if it had always been as widespread as it now seems to be. However, it would be difficult retrospectively to tease out the true increase in numbers and range of the orange ladybird, from the effects of possible earlier under-recording and the recent increase in awareness giving rise to increased frequency of sightings.

ACKNOWLEDGMENTS

I thank the following for access to museum collections, help and advice:

Geoff Hancock (Hunterian Museum), Jeanne Robinson (Glasgow Museums), J Pressly (Paisley Museum), Graham Rotheray & Keith Bland (NMS), Peter Brown (Centre for Ecology and Hydrology, Monks Wood); for records of H. 16-guttata: Glyn Collis (Bute), and the Countryside Rangers at the various Country Parks. Also, for records from other parts of Scotland: Bob Saville (The Wildlife Information Centre (TWIC), Lothians), Jon Mercer (Scottish Borders BRC, now part of TWIC), Mark Simmons (Perth Museum), Nick Littlewood (NESBReC, NE Scotland), Julie Bett (Dundee Museum), Mark Pollitt (Dumfries and Galloway BRC), and all those who have contributed records direct to Glasgow Museums BRC.

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SHORT NOTES

Grey squirrel on Great Cumbrae Island

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It is with regret that I report the first sightings of the grey squirrel (*Sciurus carolinensis*) on Great Cumbrae Island. Several reliable observers have spoken to me about having recently seen individual grey squirrels on Cumbrae: in Craigilea Wood (two sightings) and two sightings in the trees behind Marine Parade. O. S. Grid references for these sightings are, respectively: NS176564 and NS173546. The earliest sighting was made in November 2008. It is not clear whether one squirrel or several is / are involved. It seems at least possible that some misguided person has seen fit to release this alien species onto the island illegally. Although grey squirrels can swim well, using their back feet (Southern, 1964; see photograph at http://www.uksafari.com/greysquirrels5.htm) it seems unlikely that one, and most unlikely that several, might have swum across from the mainland across at least 1.75km of open sea. Grey squirrels invaded the island of Anglesey in the late 1960s (either by swimming or using the road bridge; the latter perhaps more likely given the speed of the tidal stream through the narrower Menai Strait; see http://www.redsquirrels.info/bounty.html) but no bridge spans the wider gap from the mainland to Cumbrae. Conceivably, a squirrel might have 'hitch-hiked' on a lorry coming over on the ferry from Largs. Grey squirrels have turned up on the Isle of Wight from time to time and, in 2008, a grey squirrel was speculated to have reached the Highlands on the back of a lorry carrying straw bales (Cramb, 2008), so these possibilities cannot be ruled out. Were there to prove to be several greys at large, however, this would tend to indicate a deliberate release. It is to be hoped that appropriate action might be taken to halt the spread of this unwanted interloper. Trapping has significantly reduced the grey squirrel population of Anglesey, to the benefit of their local native red squirrel (*S. vulgaris*) population. It is realised that Great Cumbrae has an insufficient quantity of joined-up woodland habitat of appropriate tree species to support a viable population of red squirrels (and none has ever been recorded from the island; see Gibson & Shillaker, 1974). So, sadly, this island could probably never become an island refuge for the native species. But the absence of the American invader had, until now, been another characteristic feature of the mammalian fauna of this island. No more. Scottish Natural Heritage has been informed of this development.

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The River Endrick ox-bow revisited

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In a previous issue of this journal, a description was given of the early stages in the transition of a newly created backwater to an ox-bow lake in the lower flood plain of the River Endrick on Loch Lomondside (Mitchell, 2004). Since then, river borne sediments have continued to build-up at both the inlet and outlet to the backwater, although trampling of these deposits of silt and sand by large numbers of summer grazing cattle is preventing the developing ox-bow lake from being completely sealed-off from the new course of the river. From a biological standpoint, this interesting site has already produced two noteworthy records. First was the appearance and establishment within the backwater of the narrow-fruited water-starwort Callitriche palustris , a species newly described for Britain and Ireland and at present known in Scotland only from the Endrick Valley (Lansdown, 2008). Then came the nesting of a pair of little ringed plovers Charadrius dubius on an exposed gravel bed in the new stretch of the river, the water level having dropped substantially during the exceptional dry spring of 2010. The parent birds successfully reared two young to the flying stage by early July, fortuitously just before all of the gravel beds were once more submerged following the resumption of the more usual rain pattern. This would appear to represent the first occurrence of the little ringed plover nesting in the Loch Lomond catchment area, reflecting a recent northward trend in the species' breeding range in this country.

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Some unpublished correspondence on the apparent nesting of ospreys on Loch Lomondside in the 1880s

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Until now, it has been assumed that the last date for ospreys *Pandion haliaetus* breeding on Loch Lomondside in the 19th century was 1829, when the pair which annually built their nest on the ruined castle of Inchgalbraith was deliberately destroyed in the supposed interest of game fish preservation (Mitchell, 1980). However, the contents of some 100 year old plus correspondence that has recently come into my possession (courtesy of J.A. Lumsden) strongly suggest that ospreys subsequently bred at other Lomondside localities in the early to mid 1880s.

In a communication from John A. Harvie Brown (then the leading authority on the vertebrate fauna of Scotland) to local naturalist James Lumsden of Arden dated 30 November 1905, Harvie Brown mentions that a fisherman by the name of James Davidson had passed on information to the effect that ospreys had been seen on Loch Lomond in the summer of 1881 or 1882. Anxious that any additional historical data should not be lost, Harvie Brown urged James Lumsden to make enquiries about any further sightings of ospreys around those years. Despite the length of time that had elapsed, Lumsden was fortunate in being able to make contact with Walter McDiarmid, a professional boatman at Luss who made a seasonal living from taking out visiting anglers including the said James Davidson to the best fishing spots on the loch.

Replying to James Lumsden in a letter postmarked 5 December 1905, McDiarmid began by saying he had first noticed two large 'hawks' which he thought might be ospreys hovering above the waters of Loch Lomond in 1880. Over the next couple of summers (when his client Davidson was able to positively identify the birds for him), a pair was regularly observed in the vicinity of Torrinch, an oak and conifer-clad island well out into the loch. He then went on to relate how from 1883 the ospreys took up new quarters at Ross Point near Sallochy on the eastern shore. For a year or two they continued to be seen in the general vicinity of the Ross Point until the oak coppice there was harvested [Note: records contained in the Montrose Estate papers confirm that the cutting of the oak coppice and remaining mature trees in this particular woodland compartment was completed in 1885 (Tittensor, 1970)]. Significantly, McDiarmid added that he had witnessed woodcutters having returned from the Ross Point to Luss had with them two birds which he took to be young ospreys from the nest. After this, he never saw the parent birds on Loch Lomondside again.

Despite the continuing background of persecution by game preservers and attention from trophy hunters, a few pairs from Scotland's original population of ospreys did manage to survive into the opening years of the 20th century, the last confirmed nesting attempt in the country taking place at Loch Loyne in Inverness-shire in 1916 (Sandeman, 1957).

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The horse chestnut scale insect on lime trees in Glasgow

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In June 2008 a number of scale insects were observed on lime trees (*Tilia sp.)* in a suburban garden on Newark Drive, Pollokshields, on the south side of Glasgow (NGR ^{2}572 ^{6}631). The scale insects were round, about 5-6mm in diameter, and each sat on a white "cotton cushion" which made them conspicuous against the dark tree bark. They were scattered on the trunk, above about 3m height, or on small groups on the underside of lower branches.. Some were also observed on sycamore (*Acer pseudoplatanus*) and a red horse chestnut (*Aesculus x carnea*) in the same garden. No such scale insects had been observed previously in this garden (occupied by MO'R) over the last 40 years. A search of the local area revealed similar infestations on lime trees throughout Maxwell Park (NGR ^{2}568 ^{6}632) and on both lime and sycamore in Titwood Park (NGR ^{2}573 ^{6}629) with one lime tree at Titwood showing a very heavy infestation (Photos 1 and 2). Similar infestations were also observed in June 2008 on trees in the car park of a bank on Fenwick Road, Giffnock (NGR ^{2}562 ^{6}591) and along the River Cart on Holmhead Crescent, Cathcart (NGR ^{2}583 ^{6}606). The scale insect infestations were again evident, though perhaps less abundant, at all these locales in June 2009 and 2010.

Some of the scale insects were removed for microscopical examination and they have been identified as the horse chestnut scale insect (*Pulvinaria regalis* – Hemiptera: Coccoidae), an alien species that is probably asian in origin.. *P. regalis* was unknown in Europe until the 1960s, when it was introduced to southern Britain and France. It has since been recorded throughout Europe including Denkark, Switzerland, Germany, Luxembourg and the Netherlands on urban trees and shrubs. The new Glasgow record is almost certainly the most northerly find in the UK (Christopher Malumphy, Pers. Comm.).

There are three scale insect species likely to be confused with *P. regalis* in the UK, i.e. brown scales with white woolly ovisacs; *Pulvinaria hydrangeae* (the cottony hydrangea scale), *Pulvinaria floccifera* (the cottony camellia scale) and *Pulvinaria vitis* (the woolly current scale). Unlike *P. regalis*, both *P. hydrangeae* and *P. floccifera* are typically found on the foliage rather than the stems/trunks of their hosts, and *P. vitis* is found on the stems and thinner branches.

All four *Pulvinaria* species are polyphagous. The number of hosts *P. regalis* is able to exploit will have facilitated its spread. Globally *P. regalis* is recorded on around 65 different host species from 24 families, *P. hydrangeae* on 19 species from 11 families, *P. floccifera* on 63 species from 35 families, and *P. vitis* on 62 species from 16 families.

Female *P. regalis* are large and rich brown (up to 7mm long). The males are smaller and paler (up to 3mm long). Males are usually present in much smaller numbers than females. The females are capable of reproducing by parthenogenesis. Eggs hatch in June-July and the first instars ('crawlers') migrate to the underside of the leaves and start to feed. In September the nymphs move to feed on the twigs through the winter. Development during this time is slow. By May they are mature and females move to the main branches and trunks to lay eggs. During these migrations many may fall from their hosts onto adjacent plants and objects. Ovisacs have been found attached to metal railings and brick walls close to lime infestations in London (Chris Malumphy Pers. Comm.). They produce up to 2000 eggs and die shortly after oviposition, whilst the eggs remain sheltered by the dead scale. Even though infestations can be extremely heavy, the main effect seems to be reducing the ornamental appeal of hosts rather than their survival.

There is considerable host overlap for the four species. With regards to the host plants observed in Glasgow so far; *P. regalis* and *P. hydrangeae* are both recorded commonly on sycamore and lime but *P. hydrangeae* normally has a more elongated white cottony extension than *P. regalis*. *P. vitis* and *P. regalis* are recorded on horse chestnut and lime but are more common on other hosts such as birch, hawthorn, peach and currant in the UK. *P. floccifera* is not recorded on any of these Glasgow hosts; it is more common on *Camelia, Ilex, Rhododendron* and *Taxus* in the UK. (see http://www.sel.barc.usda.gov/scalecgi/hostsof.exe?Family=Coccidae&genus=Pulvinaria&species=regalis&subspecies=).

With thanks to Christopher Malumphy, Invertebrate Diagnostician, Plant Health, Central Science Laboratory, York for providing information about *P. regalis* and other scale insects.

Plate 1 (a) Heavy infestation of horse chestnut scale insects on lime tree in Titwood Park. **(b)** Horse chestnut scale insects on branch of lime tree in Titwood Park.

Plate 1

a

b

The effects of the hard winter 2009-2010 on common fig trees (*Ficus carica* L.) in Dalmarnock, Uddingston and Chemilly

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Only one common fig tree (*Ficus carica* L.) is known to grow wild in Glasgow (Dickson 1991). The place is the very edge of the south-facing vertical stonework bank of the Clyde just upstream of Dalmarnock Railway Bridge (NS 613 626). It should be noted that the precarious position of this fig makes accurate, detailed observation very difficult, not to say impossible. The tree was found by JHD in 1986 during the Flora of Glasgow project. When it began to grow is unknown but it must be younger than the stonework.

In 1991 JHD wrote (page 81) that the fig had "thin multiple trunks more than three metres tall." It is still thriving, very much alive even after being reported dead in a tongue-in-cheek letter to The Herald in May 1996 written by JHD. What had happened was this. At Christmas 1995 Glasgow was the coldest place in Europe with -18, -19 and -20°C over three successive nights, as recorded at Bishopton. In May 1996 JHD visited the fig to see if the brief but very severe temperatures had had any effect and found the spindly stems to be all brown and shrivelled and some even crumbled to the touch. The tree was dead, or so it seemed. However, about a month later JRSL visited the tree and found it to be sprouting from the base and subsequently it has continued to grow.

Thirteen years later (May 2009), we returned and found the tree to be very heavily shaded because the immediately adjacent poplars and willows had grown up strongly. Now there are numerous stems several metres long and mostly very spindly, but some get better light by having grown out more of less horizontally over the river. We have never seen any attempts at fruiting.

As part of a study of the history of figs, both cultivated and wild in Britain (Dickson and Dickson 1996), in the late 1980s JHD grew some common figs from pips taken from a fig imported from Turkey. One of the saplings has been grown by JRSL in his back garden in Uddingston and it thrives, though cut back hard by the Siberian Christmas of 1995. Since then the multiple stems have reached about 5m tall (September 2009) and 2009 is the second year of attempted fruiting (Fig.1). However the fruits cannot ripen because, having grown on a tree from a ripe pip, pollination is necessary. The indispensable tiny wasp is not found north of the Loire valley in France (Dickson and Dickson 1996).

Fig. 1. The Uddingston fig with young figs which cannot ripen.

Propagated from cuttings, Common fig trees planted in Britain that produce edible fruit are cultivars not needing pollination and do not have fertile pips. Each one of the wild common fig trees in Britain derives from an imported fig and the establishment of many, perhaps the great majority, is connected with sewage.

The winter of 2009-2010 was the hardest and longest for many years, though the lowest temperature was only -10.9°C, as recorded at Bishopton. Showing no signs of winter damage, by May the Uddingston tree was growing and attempting again to produce figs; see Fig. 1. We visited the Dalmarnock tree on 8 June 2010 and again could see no injury whatsoever from freezing (Fig. 2). The thick stems overhanging the river were growing and the very spindly stems shaded by the poplars and willows were struggling on.

Fig. 2. The Dalmarnock fig showing its heavily overgrown situation.

In the spring of 2009 JHD and GM-JL planted two small common fig trees at the bottom of a south-facing

wall in Chemilly, a small village near Vesoul, the main town of Haute-Saône, a Department in northeastern France. One was the cultivar Ronde de Bordeaux and the other Madelaine des Deux Saisons. Both grew well during the warm summer and indeed grew into the autumn before being struck by frost (-5°C at Vesoul on the night of 15 October). On the night of 20 December the temperature sank to -18.5°C at Vesoul. Thereafter both young trees seemed in dire, possibly moribund state.

Fig. 3. The fig cultivar Madelaine des Deux Saisons at Chemilly with shoots strongly growing from the base in early July 2010.

However, come the spring of 2010 and they both began to sprout from the base and by mid June looked vigorous and on 7 July the largest shoot of three on Madelaine des Deux Saisons was 0.8m above soil level (Fig. 3). Baud (2007) wrote that that cultivar is very resistant to cold. A free standing Fig tree (cultivar unknown) of about six years of age in the next door garden was about 2m tall, single-trunked and well branched in the summer of 2009. It too was killed to the base but sprouted several shoots in the spring of 2010.

These observations fit well with the details concerning temperature tolerance given by Baud (2007).On page 24 he stated [Translated from French] "To damage the young stems of the year the temperature has to go down to about -12 to -14°C. Temperatures of -16 to -18°C will destroy all the aerial parts. When the aerial parts are frozen the tree produces new shoots from the base next year." The Common Fig is an adaptable, resilient tree, a point already made by Browicz (1982).

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First record of harlequin ladybird *Harmonia axyridis* (Pallas, 1773), (Coleoptera: Coccinellidae) for Glasgow

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On 28 October 2009 on the edge of Kelvingrove Park, Glasgow (NS575665) I collected a larval ladybird (see Fig 1). My attention had been drawn to it by a series of red spines on the sides of the abdomen. On closer inspection with a 10x hand lens, four pale spines on the mid abdominal dorsum became obvious. Reference to the UK Ladybird web site (www.ladybird-survey.org) indicated that the latter feature was indicative of harlequin ladybird *Harmonia axyridis*. The larva was photographed (Fig 1) and the photographs passed to various parties for their comments and identification. In due course, the Harlequin Ladybird Survey team, a collaboration between the University of Cambridge, Anglia Ruskin University and the Centre for Ecology and Hydrology, confirmed that this specimen was a harlequin ladybird. The record would appear to be the first of the species for Glasgow and the first "wild" larva to be found in Scotland. The specimen has been deposited with the Hunterian Museum, University of Glasgow (GLAHM 141553).

Native to Central Asia, the harlequin ladybird was first introduced to North America in 1916 as a biocontrol agent, principally of aphids, although it only became considered as established on the continent in 1988 (Koch 2003). In Western Europe it was first used for the same purpose in France in 1982 and since 1995 has been widely released (Brown et al 2008a). Now considered an invasive alien species on both continents, the harlequin ladybird was first recorded in Britain in 2004. Having been found in south-east England, this individual may have arrived accidentally or by natural dispersal from continental Europe. The species is also known to have arrived in Britain from Canada (Brown et al 2008b). Since 2004 the species has spread rapidly throughout much of England. The first Scottish record was in October 2007 in Orkney. It was almost certainly brought there in packaging arising from Hertfordshire (Holroyd *et al*, 2008). A further Orkney record in August 2008 is thought to have arrived with fruit or vegetables brought from the mainland (Ribbands et al, 2009). A larva in 2007 found at the Royal Botanic Gardens Edinburgh is similarly considered to have arrived with plant material (Peter Brown *pers comm.*). To the end of 2008, the latest year for which data is available, there have been nine accepted records of the species in Scotland.

Fig 1. Harlequin Ladybird larva, Kelvingrove Park October 2009. Photograph: Sandy Grant.

The Glasgow specimen was found on a metal street lighting junction box the sun-warmed surface of which was covered with many aphids and other small insects. Several adult ladybirds of three species were also present: 2-spot *Adalia bipunctata*, 10-spot *A decempunctata* and orange *Halyzia sedecimguttata*. Nearby on the adjacent park railings were two cream-spot *Calvia quatturodecimpunctata* and a single 7-spot *Coccinella septempunctata*. The harlequin larva may have been attracted by the aphids as were the other species, although the orange ladybird is a mildew feeder. In addition to being aphidophagous, the harlequin is a predator of other coccinellids and concern has been expressed that the arrival of the species may have a detrimental effect on native ladybird populations (Brown et al 2008a).

I would like to thank Sandy Grant (RSPB) for his photographs, Geoff Hancock (Hunterian Museum), Jeanne Robinson and Richard Weddle (Glasgow Museums) and Craig Macadam (Buglife) for their comments and help and Helen Roy and Peter Brown (CEH and the Harlequin Ladybird Survey) for confirming the identification and for the provision of information on the species.

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Hedgehog ticks, *Ixodes hexagonus* Leach, found attached to two dung beetles, *Geotrupes stercorosus* (Scriba), on Inchlonaig, Loch Lomond.

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Ticks (Arachnida, Acari, Ixodoidea) are ectoparasites that feed on blood and tissue fluids of mammals, reptiles and birds using their chelicerae and enzymes from salivary glands. The anterior part of the tick, the prosoma, bears chelicerae (structures for tearing skin), palps, the hypostome for attachment and four pairs of walking legs, although there are only three in the larval stage (Savory, 1977). The life cycle consists of three stages, the larva and nymph and mature adult. Ticks moult between the stages and drop from their hosts after feeding in order to moult. The common sheep tick, *Ixodes ricinus* (Linnaeus), for example, exhibit host-seeking behaviour, elevating themselves by climbing tall grasses or scrub usually to position themselves for rapid attachment to a passing host, and will respond to stimuli such as carbon dioxide, heat and odours from a potential host (Sonenshine, 1991).

The three species of *Ixodes* tick that are commonly found in Scotland (Arthur, 1963) are the sheep tick *I. ricinus*, the small mammal tick, *I. trianguliceps* Birula, (usually found on shrews), and *I. hexagonus*, the hedgehog tick (also commonly found attached to deer, dogs, birds and humans). Some ticks re-find their host after each moult within the nest or den of their hosts, especially those tick species that are restricted to a single host or a small number of related hosts (Cloudsley-Thompson, 1958).

Fig. 1. Dung beetle *G. stercorosus* showing ticks *I. hexagonus* attached.

On 15th October, 2009, during a University of Glasgow student field visit to Loch Lomondside, two beetles were found carrying seven and thirteen ticks respectively on their ventral surface (see Fig.1). They were found attached at the junctions between the protothorax and abdomen as well as the base of the walking legs (Fig. 1). The beetles were collected at two separate areas on the small island of Inchlonaig, (NS379932) and were taken to the Scottish Centre for Ecology and the Natural Environment (SCENE) field station for examination. V. Paterson identified the ticks under a microscope as *I. hexagonus*. Most specimens were adult female and probably had been feeding on the beetle's haemolymph, since they displayed engorged abdomens of a light-beige colour. Normally, having fed on the blood of vertebrate hosts, the body contents can be seen to be dark red. The host beetles were identified as the dung beetle *Geotrupes stercorosus* (Coleoptera, Geotrupidae) of north-western Britain, by E. G. Hancock, curator of Entomology at the Hunterian museum. Mammals recorded from Inchloanaig include Bank Vole *Myodes glareolus*, Mole *Talpa europaea* and Fallow Deer *Dama dama* (J. Mitchell pers. comm.,V. Paterson pers. comm.). While dung beetles are frequently infested with phoretic mites, there appears to be no references in the recent literature to ticks using them (or any other insect) as a host. It could be surmised that if their normal warm-blooded host dies, a tick might grasp any moving animal instinctively, even if this is not a suitable host. Evidence of hyperparasitism has also been recorded when male *Ixodes* have fed on females that have had a blood meal (Moorhouse *et al.*,1975). It is fairly common for parasitic insects such as feather lice to be found attached to flies or other inseets that have visited the corpse of their former avian host (e.g., Rothshild & Clay, 1952; Hancock, 1996). However, in this case, the ticks were not just holding onto beetles as 'hitch-hikers' but were apparently feeding on them; this appears to be a previously unrecorded phenomenon.

Professor Colin Adams, Victoria Paterson, Geoff Hancock and Dr Bernard Zonfrillo are thanked for their help with identification and the preparation of this note. The specimens are preserved in the Hunterian Museum (Zoology).

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Hoverfly identification training and subsequent records from central Scotland

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On 5th and 6th April 2008, 14 participants attended the first Scottish hoverfly identification training course, run by Roger Morris and Stuart Ball, co-ordinators of the Hoverfly Recording Scheme under the aegis of the Dipterists Forum. The course was subsidised by the Blodwen Lloyd Binns Trust and organised by Richard Weddle of the Glasgow Natural History Society on behalf of GNHS, Glasgow Museums and the Hunterian Museum. The aim of these training courses is to provide interested people with the knowledge to identify hoverflies. They are held in parts of Britain where records are lacking (Morris, 2009) with the records being used to contribute to an atlas on hoverfly distribution in Britain.

The initial part of this course was held at the Hunterian Museum (Zoology), Graham Kerr Building at the University of Glasgow. There were presentations on the lifestyles and ecology of various hoverflies and preserved specimens to identify. The second part of the training course was held at the University of Glasgow's Scottish Centre for Ecology and the Natural Environment (SCENE), Loch Lomond, on 13th and 14th September 2008. There was a presentation on hoverfly larvae by Graham Rotheray (Curator of Entomology, National Museums of Scotland) with fieldwork to hunt for both larvae and adult flies. In the period between the sections of the course participants were able to work on building up a reference collection.

A total of seventy species were recorded in 2008 by participants of the training course. Records came from all over the region and various habitats from gardens to bogs. The most frequently recorded species was *Eristalis pertinax,* followed by *Helophilus pendulus* and *Platycheirus albimanus*; these are common and widespread in Britain. The least recorded were generally those with a local distribution such as *Didea fasciata* and *Arctophila superbiens.* Others such as *Volucella bombylans* are more widespread and it would be expected to have recorded them more than once (this bumblebee mimic may have been overlooked). Anecdotal evidence from recorders is that several species are under-recorded in this region rather than uncommon. For example *Portevinia maculata* larvae develop in ramson bulbs, a common plant species especially in the Clyde Valley woodlands. This distinctive hoverfly has been frequently observed by various recorders since the training course. Before then it was reported rarely.

Other interesting records from 2008 (see Table 1) include *Criorhina berberina* at Chatelherault Country Park, Hamilton: this species is associated with ancient broadleaved woodlands (Stubbs & Falk, 2002) and has a mainly southern distribution in Britain with few recent records from SW Scotland (Ball and Morris, 2000). A similar distribution is seen in *Cheilosia scutellata* which favours woodland (Stubbs & Falk, 2002) and an adult was recorded on hogweed flowers at Chatelherault (M. Muir, pers. comm.). *Helophilus trivittatus* was found in its usual coastal habitat but was also recorded inland at Blantyre and this may confirm the suspected high mobility of this species (Ball & Morris, 2000; Stubbs & Falk, 2002). There were two records of *Sphegina sibirica* (in North and East Ayrshire) which was added as a British species in 1994 with a centre of population in the Highlands (Stubbs & Falk, 2002). More recent records such as these are improving the distribution knowledge of this species, and could be used to track its extent and rate of spread.

In July 2009 two course participants met at SCENE to hunt for *Syrphus admirandus* Goeldlin, 1996. A preserved specimen of this species was found in the SCENE collection (Morris, 2009). Unfortunately it was unlabelled although it is likely that it was collected in the area about 20-30 years ago. This particular attempt to confirm this as a new species to Britain was not successful. Efforts will continue to establish whether or not a population of this hoverfly does exist in Scotland. To find out more about the recording scheme and hoverflies in general, including the latest distribution maps and species information, visit www.hoverfly.org.uk

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List of hoverflies recorded:

Anasimyia lineata, Arctophila superbiens, Baccha elongata, Cheilosia grossa, C. illustrata, C. pagana, C. scutellata, C. variabilis, Chrysogaster solstitialis, Chrysotoxum arcuatum, Criorhina berberina, Dasysyrphus albostriatus, D. venustus, Didea fasciata, Epistrophe eligans, E. grossulariae, Episyrphus balteatus, Eristalis abusivus, E. arbustorum, E. horticola, E. interruptus, E. intricarius, E. pertinax, E. tenax, Eupeodes corollae, E. latifasciatus, E. luniger, Helophilus pendulus, H. trivittatus, Lejogaster metallina, Leucozona glaucia, L. laternaria, L. lucorum, Melanostoma mellinum, M. scalare, Meliscaeva auricollis, M. cinctella, Merodon equestris, Myathropa florea, Neoascia obliqua, N. tenur, Pipiza noctiluca, Platycheirus albimanus, P. ambiguus, P. angustatus, P. clypeatus, P. europaeus, P. granditarsus, P. nielseni, P. peltatus, P. perpallidus, P. rosarum, P. scambus, P. sticticus, Portevinia maculata, Pyrophaena granditarsa, Rhingia campestris, Scaeva pyrastri, Sericomyia silentis, Sphaerophoria interrupta, S. scripta, Sphegina clunipes, S. sibirica, Syritta pipiens, Syrphus ribesii, S. torvus, S. vitipennis/rectus, S. vitripennis, Volucella bombylans, V. pellucens, Xylota sylvarum.

Species	Location	Grid ref	Date
Arctophila superbiens	Mugdock Wood, Mugdock	NS545767	06/09/2008
Cheilosia scutellata	Chatelherault Country Park, Hamilton	NS734537	24/07/2008
Criorhina berberina	Chatelherault Country Park, Hamilton	NS734537	12/05/2008
Didea fasciata	Culzean Country Park, Ayrshire	NS233102	20/07/2008
Epistrophe eligans	Seamill, nr West Kilbride	NS203467	10/05/2008
Epistrophe eligans	Ayr Gorge Woodlands Nature Reserve, Failford	NS460256	20/05/2008
Epistrophe eligans	Chesterhill, Anstruther West	NO563032	04/04/2008
Epistrophe eligans	Glasgow Necropolis, Glasgow	NS604654	08/05/2008
Epistrophe eligans	Shewalton Pits Nature Reserve, Shewalton	NS327371	14/05/2008
Eupeodes latifasciatus	Gailes Marsh Nature Reserve, Irvine	NS326357	20/06/2008
Helophilus trivittatus	Seamill, nr West Kilbride	NS203467	03/08/2008
Helophilus trivittatus	David Livingstone Centre, Blantyre	NS694585	07/07/2008
Neoascia obliqua	Coulter, nr Biggar	NT026337	31/05/2008
Pipiza noctiluca	Gailes Marsh Nature Reserve, Irvine	NS326357	29/06/2008
Platycheirus europaeus	Shewalton Pits Nature Reserve, Shewalton	NS327371	14/05/2008
Platycheirus perpallidus	Shewalton Wood Nature Reserve, Shewalton	NS344350	24/06/2008
Platycheirus sticticus	Drumchapel, Glasgow	NS5371	30/06/2008
Sphaerophoria scripta	Gailes Marsh Nature Reserve, Irvine	NS326357	03/06/2008
Sphegina sibirica	Barony Bing, nr Cumnock	NS528212	04/07/2008
Sphegina sibirica	Corsehillmuir Wood Nature Reserve, Kilwinning	NS315434	19/08/2008

Table 1. Selected hoverfly records of species that are scarcely distributed in central Scotland.

Some significant women in the early years of The Natural History Society of Glasgow

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The early constitution of The Natural History Society of Glasgow (NHSG) did not explicitly exclude women members (e.g. NHSG, 1873), however there were no women named in membership lists until 1886. In 1887 amendments to the constitution, which were adopted in 1888 (NHSG, 1888), included waiving the entry fee for women, though they were still asked to pay the annual subscription. However, prior to this, the Proceedings note the admission of two women in October 1882: Miss Adelaide Broadhurst and Miss Josephine McKean (NHSG, 1882). This is not to say that during the early years women played no role in Natural History in general, nor in NHSG in particular. There are several earlier references in the Proceedings to Elizabeth Gray and to Hannah Robertson – though invariably as 'Mrs Robert Gray' and 'Mrs David Robertson' respectively. This note attempts to shine a little light on these women, particularly the latter two, and to put them in the context of contemporary events. Both Elizabeth Gray and Hannah Robertson were made honorary members of the Society in 1901. It seems particularly appropriate to publish this account in 2010, the centenary of the death of Hannah Robertson.

Elizabeth Gray

Elizabeth Gray (née Anderson, 1831–1924) was the wife of Robert Gray, one of the founder members of NHSG; her interest was fossils. The Proceedings on several occasions mention specimens which she had provided for display at meetings of the Society; these included a graptolite which she had found and which, it was proposed, should be named *Cyrtograpsus grayianus* in her honour (NHSG, 1872). The same entry mentions her specimen cabinet from which 'several groups of fossils have already been brought before the society'. These are reported in the Proceedings as having been brought to meetings by Robert Gray or by Prof. Lapworth. The species *Cyrtograpsus grayae* Lapworth is listed in the Handbook produced for the 1901 meeting of The British Association for the Advancement of Science in Glasgow (Peach, 1901) as having been found near Girvan; this is presumably the species displayed in 1872. The extensive list of fossils from the Girvan area included in the Handbook is partly derived from 'Mrs Gray's list of fossils published in ….. The Silurian Rocks of Scotland' and, among the species (of diverse taxonomic groups) listed, there are a further dozen with the specific names *grayi*, *grayae*, or *grayana*. Most of her collection is now in the Natural History Museum London, though there are specimens in the Hunterian Museum in Glasgow (Neil Clark, pers. comm.) and in other locations. Elizabeth and Robert moved to Edinburgh in 1874, some 8 years before women were first admitted to GNHS as members. However, when Professor Young instituted a class in geology for women at Glasgow University, he presented a ticket to Mrs Gray - her only formal geological education. It appears that she acquired her initial knowledge through fossil-collecting expeditions with her father (McCance, 2002). The Oxford Dictionary of National Biography (ODNB, 2009) notes that "In 1900 Elizabeth Gray was made an honorary member of the Geological Society of Glasgow for the contribution her collections had made to geological literature. The Murchison geological fund was awarded to her in 1903 in recognition of her skilful services to geological science. A woman of considerable character, determination, and resourcefulness, with a phenomenally retentive memory, she was renowned for her extensive collecting in the Girvan district, which she carried on until the autumn of 1923". In 1901 she was made an Honorary Member of the Natural History Society of Glasgow.

Hannah Robertson

Hannah Robertson (née Alston c.1826-1910) was the second wife of David Robertson, the eminent marine biologist of Cumbrae, who joined NHSG in 1852, a year after it was founded, and about 9 years after marrying Hannah. David Robertson's obituary (NHSG,1897) describes how Hannah, as a teenager living on the Isle of Man, had collected sea-shells 'for the benefit of a great conchological signboard' Robertson was making. When they eventually met (in Glasgow) they apparently took to each other immediately and married just over a year later; she was about 20 years his junior. When David retired in 1860, the Robertsons moved to Cumbrae, where Hannah 'assisted her husband in his favourite departments of research' and 'turned her attention to the study of the recent Foraminifera of which she has formed a large and valuable collection' (NHSG,1897). She accompanied him on many of his dredging excursions (mainly in the Firth of Clyde), and together they visited the east of Scotland, Orkney and Norway to collect marine fossils. After her husband's death (in 1897) Hannah compiled an impressive list of Foraminifera for the 1901 Handbook (Robertson, 1901). The list of marine algae in the same volume refers to many records from the Robertsons' collection, and in the introduction to that list, Batters asserts that '… it is to the efforts of the indefatigable Mrs Robertson …. that we owe most of our knowledge of the marine algae of the Firth of Clyde.' Hannah also continued to contribute specimens for display at NHSG meetings; the Transactions in question do not specify whether she sent them or whether she herself was present at the

meeting. One such specimen was a marine alga new to Britain: *Phaeosaccion collinsii* found on Cumbrae, and previously only known from North America and Greenland (NSHG, 1899). After Hannah's death in 1910, her collection of marine algae and microzoa went to Glasgow Museums; the Glasgow Museums and Art Galleries Report for the Year 1914 describes this as 'the most important addition to the Natural History Department during the past year'. The collection of marine algae numbered some 1,000 specimens; and then referring to the Foraminifera, the Report describes how she 'built up a valuable collection of these minute but beautiful forms'; the collection also included Ostracods from the Clyde valley. She was apparently never a member of GNHS in her own right until she was made an Honorary Member in 1901, though she was a founder member of the Marine Biological Association of the West of Scotland (MBAWS, 1910).

Adelaide Broadhurst and Josephine McKean

As mentioned above, these two women were admitted to the Society in October 1882 (NHSG, 1882). It was Adelaide Broadhurst's name which appeared in the 1886 membership list (NHSG, 1887), but neither she nor Josephine McKean is listed in the membership list published in 1883 which probably represents the membership list up to the date of the 1882 Annual General Meeting, which would have taken place prior to October (NHSG, 1883). Both were junior teachers at The Park School for Girls when it opened in Lynedoch Street (Sept 1st 1880), and their address is given as such in the Proceedings. Adelaide Broadhurst taught science at an annual salary of £100 (the headmistress was paid £400 p.a). She had formerly taught at Liverpool Ladies' College, and up until the time she left The Park School, about 8 years later, 'the demands on the chemistry department were constantly increasing, as was its success' (Lightwood, 1990). It seems likely that she is the Mary Adelaide Broadhurst recorded as a teacher in the 1881 census, and resident (with her parents, siblings, and a servant) in Chorlton-on-Medlock, then on the southern edge of Manchester, and now largely occupied by more recent developments including the University of Manchester.

Josephine McKean taught mathematics (at The Park School), and was also paid £100 p.a. She appears to have left the Society within a year or two of joining, as there is no further mention of her in the in the Proceedings and Transactions after October 1882. The History of the Park School (Lightwood, 1990) does not mention her again either, though this may imply that she continued after Adelaide Broadhurst had left, as the latter is mentioned as one of the first to move on.

HISTORICAL CONTEXT

The two young teachers may be exemplars of political concerns at that time over the number of 'superfluous', unmarried women in the population; young women often aspired to become teachers or governesses rather than to marry, and were actively encouraged to emigrate, as witnessed by the existence of the Female Middle Class Emigration Society (www.archiveshub.ac.uk/news/0806fmces.html (2009)). It seems possible that both teachers emigrated, as I have been unable to find any subsequent public record of either of them (Census, Marriage or Death). More immediately, their membership of the Society may have owed something to Prof. John Young, who was a founder member of the (Glasgow) Association for the Higher Education of Women, a Director of The Park School for Girls, and a member of the Council of NHSG, as well as being Professor of Natural History in the University of Glasgow. Unfortunately the minutes of the Society do not record details of any discussions on this topic. And, as noted above, Prof. Young had previously enrolled Elizabeth Gray into the Geology class at the University. The recently published book by Finnegan (Finnegan, 2009), gives interesting comparisons with natural history societies elsewhere in Scotland and other useful contextual information. Among the themes he explores are a wish to project an image of natural history as a 'manly' pursuit, requiring strength and stamina, and the role of women (in some other natural history societies) in organising fund-raising bazaars. I commend the interested reader to that book (reviewed elsewhere in this issue) for details. Finnegan also gives a table comparing the dates of admission of women members and the rate at which women took advantage of this in some of the Scottish societies, though he appears to have missed the Misses Broadhurst and McKean, and therefore gives a later date for NHSG. Nevertheless, NHSG and the Andersonian Naturalists' Society (also of Glasgow) appear to have been the last two of the 10 larger Scottish societies to enrol women as members. Creese supplies further context, spreading a rather wider comparative net including information about nineteenth century women scientists in Ireland, Scandinavia and other parts of Europe, though unfortunately she cites no Scottish examples (Creese, 2004). Incidentally, the original constitution (1885) of the Andersonian Naturalists, like that of NHSG, did not explicitly specify 'gentlemen', nevertheless, the wording was changed in 1886 (ANS, 1886) to 'Ladies or Gentlemen', and 'ladies shall be admitted free'. By 1889-90, 14 women were listed as Ordinary Members (of NHSG) and 4 as Associate Members, one of whom was the wife of an Ordinary Member. This had dropped to 6 and 3 respectively by 1893, all but one of whom had joined before 1890. There is no record in the Proceedings of any of them organising a bazaar! But it was not apparently until the 20th century that a woman member read a paper to the Society or personally exhibited specimens at a meeting. In 1902, Mrs Ewing (wife of the then President, Peter Ewing) read a paper to the Society "Arctic Plants from the Dovrefeld, Norway" and exhibited the plants mentioned (NHSG, 1902); and in 1903 Wanda Zamorska exhibited botanical specimens from Ruchill and Glen Clova (NHSG, 1903) – she had joined the Society, with her two sisters, in 1894. By January

2010, there were 117 men and 118 women members of GNHS.

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I am grateful to Alison Sutcliffe for drawing my attention to the 1881 census record for Adelaide Broadhurst; to Richard Sutcliffe for information about Hannah Robertson's collections and for helpful comments; to Avril Walkinshaw for lending me her copy of The Park School 1880-1980; to Geoff Moore (Millport Marine Station) for the information on Hannah Robertson; to Neil Clark (Curator of Palaeontology, Hunterian Museum) for biographical information on Elizabeth Gray, and finally to Diarmid Finnegan for publishing his book before I had finalised the above account, thereby saving me much further research.

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Bats in the West End of Glasgow (Chiroptera: Pipistrellus sp., *Myotis daubentonii, Plecotus auritus*)

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A recent Short Note (MacNaught, D. Bats in Clarence Drive; The Glasgow Naturalist 24 (2), 143) described bats patrolling a floodlit football pitch (NS556672) in the late evening. The likelihood is that these were species of Pipistrelle (*Pipistrellus pipistrellus* or *P. pygmaeus*), though there is a record of brown long-eared bat (*Plecotus auritus*) in a nearby tenement (Sutcliffe, R. (1989); Glasgow Museums Biological Records Centre). The Glasgow Museums BRC has few other records of bats in this area, and there appear to be none in the public domain, so this note reports further investigations into the species and habits of bats in Hyndland, Partickhill, and other locations in the West End of Glasgow, in the years 2008 and 2009. The bats' calls were detected using a Batbox Duet detector (Alana Ecology, Bishop's Castle, Shropshire) linked to an Edirol R-09 digital recorder (Studiospares, London); the recordings were analysed using BatScan software (Alana Ecology). All records included in this report are the author's own observations unless otherwise indicated. The common (45kHz) pipistrelle (*P. pipistrellus*) has often been detected – and occasionally seen – principally in a small woodland alongside the north end of Hayburn Lane, behind Novar Drive (NS556676), in the adjacent wooded area of Hyndland Old Station Park (NS558676), and in the trees around the (well-lit) childrens play area in Novar Drive (NS557675). In nearby Partickhill, the same species has been heard in the mature trees in the gardens and streets of the area defined by Turnberry Road, Banavie Road and Partickhill Road. It has also been seen feeding in the small park, adjacent to that area, at the southern end of Hayburn Lane and at east end of Hayburn Crescent (NS554669). It would be possible for bats to follow a tree-lined path along the whole length of Hayburn Lane from Hyndland Old Station Park, through the above-mentioned woodlands behind Novar Drive, and along the railway embankment, to this small (and apparently unnamed) park. No more than one bat has been recorded on any one time in any of these locations; though this does not rule out the possibility of a succession of single bats moving through the area.

However, a resident of a house overlooking Dowanhill Park (NS561669) reported frequent sightings of up to five individuals flying there; following this report, a single common pipistrelle was seen and identified from a recording of its call on two separate occasions.

The common Pipistrelle, the soprano (55kHz) pipistrelle (*P. pygmaeus*) and Daubenton's bat (*Myotis daubentonii*) have all been recorded – and the latter seen by torchlight - along the River Kelvin at Glasgow Botanic Gardens and downstream to the weir below Kelvinbridge. The region further downstream was not investigated, though there are prior records of all three species, and of brown long-eared bat (*Plecotus auritus*), from Kelvingrove Park (Glasgow Museums Biological Record Centre). Soprano pipistrelle has also been recorded at Bingham's Pond (NS555682) and in a garden in North Woodlands Road (NS577670). The call of the brown long-eared bat is difficult to detect and record using the techniques described; to determine whether it is still present in the area would probably require more direct methods such as searching roof-spaces. It is known to favour 'traditional attic' spaces, such as might be found in the detached and semi-detached houses of Partickhill (Entwhistle, A.C. et al., Roost Selection by the brown long-eared bat *Plecotus auritus*, Journal of Applied Ecology 1997, 34, 399-408), though it is possible that recent 'home improvements' may have reduced the accessibility and or suitability of these locations.

The main focus of aim of this research was to investigate which species were present and how widely they range. It was interesting to find that both Pipistrelle species were present in this urban setting, and that the common pipistrelle takes advantage of the tree-cover over the whole area. In this respect 'connectivity' is no doubt very important – that is, that there are no significant gaps in the tree coverage – this could become an issue as the existing trees reach the end of their natural life-span. Also it has been suggested (K. Cohen, pers. comm.) that *P. pipistrellus* is more of a habitat generalist than *P. pygmaeus*, the latter being less frequent in, as opposed to around, built-up areas; there is insufficient data in these findings to comment on this, though there is a suggestion of an association between *pygmaeus* and trees bordering water (Bingham's Pond and near the River Kelvin). A study of habitat preference would form a useful basis for further research; it would also be interesting to discover the roost sites being used. These records, like all mammal records from the Glasgow Museums BRC database, can be viewed at http://data.nbn.org.uk/ by typing the species name in the Search box. Records can also be supplied on request from Glasgow Museums BRC: biological.records@glasgowlife.org.uk

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Water beetles from St Kilda, an annotated list

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INTRODUCTION

A number of visiting naturalists have collected water beetles, amongst other things, when landed on St Kilda. Occasionally these visits were opportunistic but several were planned specifically for surveying the archipelago, or parts of it, for faunistic purposes. Recently we have reported on millipedes (Hancock, et al., 2008), the endemic weevil (Robinson & Hancock, 2008) and caddis flies (Robinson, 2009). The water beetle records given here are from literature and recent fieldwork. In the latter case these confirm the older observations and allow their reappraisal, with the addition of one dytiscid species, *Agabus nebulosus*. An old record of *Helophorus griseus* is regarded as unlikely and is removed from the list. To add interest to this short article, notes on the various naturalists or collectors involved are included.

Dytiscidae

Agabus bipustulatus (Linn.). Listed as var. *solieri* and 'common' according to Hewitt (Beare, 1908); (Lack, 1931); in standing open water (Hamilton, 1963); six examples under stones, near Amazon House and one female at The Tunnel, R. Hendry, 16-22 May 1994; found in pools at An Lag, Cambir, Mullach Sgar, Hancock & Robinson, 2006.

Agabus guttatus (Paykull). Found by Luff & Davies (1972).

Agabus nebulosus (Forster, 1771). One adult, pool on Mullach Sgar, Hancock and Robinson, 1-8.vii.2006.

Hydroporus gyllenhalii Schiödte. Found by Luff & Davies (1972).

Hydroporus longulus Mulsant. Found by Luff & Davies (1972), confirmed by Waterston (1981) and of 'Nationally Scarce' RDB status. The specimens are in the collection of the National Museum of Scotland and labelled as from pitfall traps set at The Gap, 5-8 July 1970 (pers. comm., G.N. Foster). Balfour-Browne (1940) gives its habitat as mossy or peaty streams, in springs, wells and trickles.

Hydroporus memnonius Nicolai. Collected on Boreray (Duncan, et al., 1981). This species is common in the Faeroes, comparable to St Kilda in isolation and habitat, and so although the identification from Boreray was originally given as tentative, it is undoubtedly correct.

Hydroporus obsoletus Aubé. This is believed to be the identity of the single specimen recorded as *Hydroporus ferrugineus* Stephens from St Kilda by Beare (1908). This latter is the name for a truly subterranean species, with reduced eyes and is flightless. The two species have often been confused in the past. Hudson Beare's collection in the National Museum of Scotland (NMS) has been searched but there is no sign of the specimen to be able to confirm this. There are records of *H. obsoletus* from several other isolated islands, including the Outer Hebrides. It is regarded as a "semi-subterranean" species and can fly, unlike *H. ferrugineus*.

Hydroporus pubescens (Gyllenhall). Very common in marshy places, (Beare, 1908); (Lack, 1931); in standing open water (Hamilton, 1963).

Hydrophilidae

Helophorus flavipes (Fabr.). As *H. aenipennis* Thomson, (Beare, 1908); (Lack, 1931); 'unusually small' (Lack, 1932); in a well in village area (Hamilton, 1963); (Luff & Davies, 1972); one specimen, 14-24 June 2004, Hunterian Museum. Due to nomenclatural confusion the record of *H. quadrisignatus* as given in Beare (1908) will refer also to this taxon.

Helophorus obscurus Mulsant. Boreray (Duncan, et al., 1981). There are three modern records of this species from Barra otherwise this isolated record might have been considered doubtful.

Cercyon impressus (Sturm). Boreray (Duncan, et al., 1981), as *C. atomarius* (Fabr.).

Cercyon haemorrhoidalis (Fabr.). One specimen (Beare, 1916).

Cercyon littoralis (Gyll.). Very common in gannet and shag nests made of seaweed (Joy, 1908).

Cercyon melanocephalus (L.). Previously mis-identified as *flavipes* (Fabr.). One specimen (Beare, 1908); (Joy, 1908); (Lack, 1931); given as new to island by Luff & Davies (1972); Boreray (Duncan, et al., 1981).

Megasternum concinnum (Marsham) (= *obscurum* (Marsham)). Recorded heretofore as *M. boletophagum*. The understanding of which name(s) will apply to the British species may change again due to some current but as yet unpublished work (pers. comm., G.N. Foster). Four specimens (Beare, 1908); (Joy, 1908); common (Lack, 1931); Boreray (Duncan, et al., 1981); 1 June 2004, Hancock; in quarry, 1-8 July 2006, Hancock & Robinson.

Anacaena globulus (Paykull). Three specimens (Beare, 1908); common (Lack, 1931); Boreray (Duncan, et al., 1981); 1 June 2004, Hancock; 1-8 July 2006, Hancock & Robinson.

Hydraenidae

Ochthebius dilatatus Stephens. An atypical pale yellowish-coloured adult in roots of scurvy grass, Glen Bay, 1 June 2004, Hancock, and another but of uniformly dark colouration under loose boulders, Ruaival, 12 June 2008, Hancock, specimens in Hunterian Museum, det. G.N. Foster. A pale *Ochthebius* specimen from St Kilda was found in the Natural History Museum, London, in the Lack collection, without a determination label but presumably is the source of the published record of

Ochthebius rufimarginatus Stephens from Ruaival (Lack, 1931). On critical examination by G.N. Foster it proved to be another example of *dilatatus*. A single specimen of *O. dilatatus* was located in NMS, collected on the Flannan Islands by W.A. Page, June 1959, and is also paler than examples of this species found on the British mainland. Variation in colour of these individuals in isolated small populations may parallel the situation seen in the weevil *Ceutorhynchus insularis* which is typically a black species but is highly variable on St Kilda (see Love, 2009, plate 13). Finally, two pale specimens from the Cable Cleft, Isle of May, July 1964, collected by M. Smith, in NMS were examined, one of which is pale due to being teneral (full mature colouration not fully developed) and the other is faded. The position of Isle of May would be expected to mitigate against variation because of the high possibility of interchange of individuals to and from the mainland.

Scirtidae

Elodes pseudominuta Klausnitzer. Five specimens (Beare, 1908); (Lack, 1931); unusually small and dark (Lack,1932); in small pools and streams (Hamilton, 1963); Glen Bay, Hancock, 2004, det. G.N. Foster. The critical examination of this last specimen confirms that the earlier records named as *Helodes minuta* (Linn.) relate to this species. It has been found recently in the Faeroes (Hansen & Foster, 2009).

Past record regarded as doubtful

Helophorus griseus Herbst. Recorded as *affinis* (Marsham) by Beare (1908), but this species is rare in Scotland and the record dates from when names were confused and so wrongly applied to some records.

Personnel involved in collecting and/or recording on St Kilda

DAVIES, Lewis, University of Durham, accompanied by John Richardson, mainly used pitfall traps on Hirta plus some hand searching, 28 June – 10 July 1970 (Davies, 1980; Luff & Davies, 1972). Many specimens were deposited in the National Museum of Scotland, Edinburgh.

DUNCAN, N with D. Bullock and K. Taylor, students from the Zoology Dept (Durham University), camped on Boreray in 1981 for several days. Identifications of invertebrates were provided by a number of experts in the various groups. The unpublished report from this expedition is used as a source here, bringing the records more into the public domain.

HANCOCK, E. Geoffrey, Hunterian Museum, University of Glasgow, visited briefly 31 May-1 June 2004 and on 12th June 2008, when insects were hand-collected and swept mainly from Village Bay, Gleann Mór, and Glen Bay. Also visited twice with Jeanne Robinson (q.v.) for more structured collecting, 31 May – 7 June 2005 and 1-8 July 2006. Specimens deposited in Hunterian Museum.

HENDRY, Dick, then the chief natural history technical officer based at Kelvingrove (Glasgow Museums) visited Hirta from 16-22 May 1994. The purpose was to make records in advance of building replica cleits, a black house and associated items for an exhibition. The opportunity to collect some invertebrates resulted in a list of species, identified by E.G. Hancock and preserved in Glasgow Museums.

HEWITT, Charles Gordon (1885-1920), based in Manchester, visited St Kilda during July 1906. He identified and recorded the non-insect arthropods himself (Hewitt, 1907) but the Coleoptera were examined by J. R. Hardy of Manchester Museum and these results were incorporated by Beare (1908). Hewitt emigrated to Canada in 1909 where he became the Dominion Entomologist, later consulting zoologist to the Canadian Commission of Conservation (Anon., 1920).

JOY, Norman Humbert (1874-1953), did not visit St Kilda but engaged a man, contacted *via* Newstead, (q.v.), who visited St Kilda every year to collected birds' nests (Joy, 1908 and 1909). The name of this man is not given but may have been the Manchester-based commercial egg and skin collector Harry Brazenor (Harvie-Browne, et al. 1908). Thus, Joy obtained the nests of cormorants, gannets and puffins, plus haystack refuse, sheep dung and sphagnum. On 28 Sept 1908, although Joy had requested just grass and moss, a sack full of earth and large pieces of turf was delivered but nevertheless several previously un-recorded beetles were extracted.

LACK, David (1910-1973), ecologist from Magdalene College, Cambridge, visited St Kilda 22 July- 13 August 1931, as one of a party from Oxford and Cambridge. Specimens are deposited in Natural History Museum London (acc. no. BM.1931-381) apart from the Thysanura in Manchester Museum (Lack, 1932).

NEWSTEAD, Robert (1859-1947), a formally unqualified museum curator, at the Grosvenor Museum, Chester who later became Professor of the Liverpool School of Tropical Medicine. Recorded scale insects (Homoptera, Coccoidea) on the basis of having visited St Kilda during June 1902 as part of a tour of the Western Hebrides (Newstead, 1903). He was able to help Joy (q.v.) obtain beetle samples.

ROBINSON, Jeanne, curator of entomology for Glasgow Museums, visited twice, 31 May – 7 June 2005 and 1-8 July 2006; specimens deposited in Glasgow Museums.

WATERSTON, Dr James (1879-1930), collected on Hirta from 17 June-17 July 1905 and referred to as Mr James Waterston, M.A. of Edinburgh (Evans, 1906) but only slightly later as the Reverend James Waterston, B.D., B.Sc. (Grimshaw, 1907). He abandoned the church for a secular career in science (Laing, 1930) and moved to London in 1913 and in 1920 became a full-time entomologist in the British Museum (Natural History). His Coleoptera from St Kilda were identified by Beare (1908) and indicated as such in that note. His son, A. Rodger Waterston (1912-1996), curator in the National Museum of Scotland, Edinburgh, compiled the comprehensive Outer Hebrides list (Waterston, 1981) and identified samples deposited by a number of visitors to St Kilda.

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A long-tailed blue butterfly, *Lampides boeticus* (Linn.), import to Glasgow

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The long-tailed blue butterfly is an unusual species in being of worldwide distribution in warm climates. Beyond there it occurs only as a migrant and is not permanently resident at higher latitudes with cooler and variable climates. In western Europe it does not appear to become established for any length of time beyond the Mediterranean region. The long-tailed blue is reported occasionally in southern England as a migrant but rarely more than one or two are seen in any one year. Apart from this it can be transported with vegetable produce.

On 25 May 2009, one pod from a packet of mangestous peas bought in Glasgow, was found to be externally damaged and when examined a living caterpillar was seen inside. The produce was from Kenya. After being brought to the museum it pupated and an adult butterfly emerged on 14 June 2009 (Fig. 1). There have been several occasions on which this butterfly has been found in Britain and Ireland following the purchase of fresh peas grown in Africa. This might appear to have quite a long historical precedence as it was called the pea-pod argus at least from the time of Newman (1870-71, *The illustrated natural history of British butterflies*, London, p. 117).

However, this was originally in connection with its natural feeding habits on lupins, garden peas and other legumes. Only recently, with the extensive export of fresh peas from Africa, has that name come to be widely used in the context of extra-limital findings, including Australia and New Zealand. In southern Britain this phenomenon has implications for species recording as the distinction between escapees from shops or kitchens and genuine migrant individuals is not always clear.

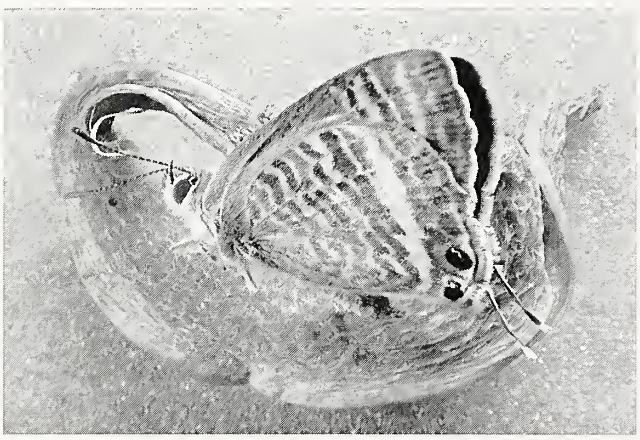

Fig. 1. Long-tailed blue after emergence from a pea pod from Kenya alongside its empty chrysalis (Hunterian Museum, Reg. No. 141277). When alive, the tails at the apex of the hind wing are flicked backwards and forwards which together with the false eye spots bears a convincing resemblance to a head and antennae. Predators focus on the wrong end of the insect and any attack is deflected from the more vulnerable part.

Hitherto, there has been only one reported occurrence of the long-tailed blue in Scotland when a specimen from Ardrossan was shown at a meeting by J.J.F.X. King (1884, Proceedings of the Glasgow Natural History Society, volume 5, p.213), collected in July 1881. King, in his comment on the exhibit, 'thought probably [it] had been accidentally introduced' but was not able to identify a specific source. Thomson (1980, *The butterflies of Scotland*, London, pp. 108-9) discusses King's record in the context of the species being a very rare migrant to the United Kingdom but there is no evidence that the long-tailed blue has arrived in Scotland by natural means. There are no specimens of local origin in the National Museum of Scotland (pers. comm., Keith Bland, 8th December 2009).

Paul Walton and Norman Storie are thanked for detecting and passing the pod to the Hunterian Museum.

Pine martens, *Martes martes* as predators of nestling blue tits, *Cyanistes caeruleus*

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For ~20 years nest boxes around the Scottish Centre for Ecology and the Natural Environment (SCENE) and Cashel Farm on the east banks of Loch Lomond have been employed to study the breeding behaviour of blue tits, *Cyanistes caeruleus*. The nest boxes have also been used albeit infrequently by Pied Flycatchers, *Ficedula hypoleuca* and Redstarts, *Phoenicurus phoenicurus* both amber listed species. The woodcrete nest boxes (Schwegler) are suspended from mature oak trees by a 35cm metal bracket perpendicular to the trunk. In previous years birds breeding in the nest boxes have rarely encountered predation. On only one occasion a greater spotted woodpecker, *Dendrocopos major*, a common predator of nestling passerines, successfully consumed blue tit nestlings (Pers. Obs.).

For the past two years I have been monitoring the breeding blue tits for my PhD thesis, and in order to expand the field site additional boxes were added. However, unlike the older boxes they were hung directly on the tree from a nail rather than a bracket (See Fig. 1). The second breeding season after these boxes were put in place, three out of ~100 broods (shortly after hatching) were found dead, although there was no apparent injury to the nestlings themselves. The nestlings were also covered in blood which was not their own. Therefore, I concluded that the breeding adult had been predated while brooding and the nestlings had died of starvation. Later in the nestling stage, always after nestlings were 10 days old, blue tit broods began disappearing prior to fledging. The characteristics of each predation event were the same and as before, predation only occurred in nest boxes hung directly upon trees. The nest was always removed from the box and found directly beneath on the ground. In some cases there were also a few nestling feathers (identified because they were still in pin) found on the nest box or below. I was able to infer that the predator was mammalian from these remains as feathers had been bitten through rather than plucked as seen after avian predation (Hudson *et al.*, 1997).

Fig. 1. a) The recently established nest boxes hung from nails placed directly onto trees and b) the older nest boxes hung from a metal bracket.

At the Cashel Farm site where the majority of the new boxes had been placed, every occupied nest box (35 broods) was predated in the same manner, with not one nestling surviving to fledge. On one occasion when going to weigh nestlings as part of my research I interrupted a pine marten, *Martes martes* sitting on top of one of the nest boxes pulling out nestlings through the entrance hole. When I was about 20m from the nest the individual saw me and ran into the woodland. When I arrived the majority of the nest had been pulled out of the box presumably bringing the nestlings with it. The pine marten had consumed the majority of the brood, one was found partially consumed on the ground below and only two of the ten nestlings remained in the nest box with little remaining nest material. When returning to the nest box a few days later the last two nestlings had disappeared.

My experience serves to highlight how effective a predator pine martens can be for hole nesting passerines. In addition, the fact that the majority of the broods were predated 10 days after hatching when nestlings are almost adult sized indicates that something about this stage of development attracts pine martens. There are a couple of reasons why this may be the case; fledglings are very vocal at this time and may draw attention to their presence, or simply that pine martens cannot reach nestlings until they are larger and therefore closer to the entrance hole. It is important to note that nests placed on brackets between and within 20m of predated boxes did not experience predation. Therefore this simple precaution may help to avoid predation events. The predated nests were predominately at one site but they also extended over 3km. There is evidence that elsewhere in Europe pine martens can move 8.5km per day during the summer months (Zalewski *et al.*, 2004), therefore it is possible that these predation events were carried out by the same individual or more than one individual from a neighbouring territory. Pine martens have been documented to prey upon birds in Scotland (Paterson & Skipper, 2008; Putman, 2000; Halliwell, 1997; Gurnell *et al.*, 1994; Balharry, 1993; Lockie, 1964) with particular reference being made to passerine predation

in some cases (e.g. Putman, 2000; Halliwell, 1997). There is also evidence that bird predation by pine martens is seasonal having a higher occurrence in the diet during winter months (e.g. Putman, 2000; Gurnell *et al.*, 1994). However, bird predation does occur at other times of the year with at least one study showing an increase in bird predation during spring and summer (Balharry, 1993). My observations indicate that pine martens are potentially a voracious predator of breeding passerines. However, as the predation event documented here was related to man-made nest structures only, this level of predation rate may not be similar for naturally nesting birds.

ACKNOWLEDGEMENTS
I would like to thank all those who were involved in the blue tit project in 2009, particularly those involved in the joyless task of identifying and recording the large number of predation events that year; Dr K. Arnold, Dr B. Heidinger, Dr C. Foote, Ms C. Fischbacher, Ms S. Bairner, Ms C. McGeachie, Ms E. Lowe, Ms J. Desjardins, & Ms G. Ortolani.

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House sparrow counts at an Uddingston garden

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In the year 2000 the late Professor Norman Grist asked us to count sparrows as he had noticed the numbers were falling in his garden in the west end of Glasgow. Sparrows were counted on the first of each month in the back garden. They perched on the hedge and particularly liked to eat the *Forsythia* flower buds in the spring and the seeds of *Clematis tangutica* in the autumn. Bird feeders were put out from September to May. An obvious dip can be seen in numbers between May and September when feeders were removed (Table 1). Summer numbers may have been augmented by young fledglings. Overall, there was a marked decline in counts of sparrows throughout the 10 year period (Fig.1). During this period it should be noted that the sparrows were disturbed by building work next door in Mareh 2006, the hedge next door dug up in September 2006, and the fence painted in June.2007. In April 2009 the large *Leylandia* hedge was cut down and from October to February the school beside our garden was demolished. January and February 2010 were the coldest for approximately 50 years (Meterological Office, 2010). These disturbances may explain the drop in numbers from September 2009, "Within urban areas, House Sparrows may have disappeared from more affluent areas, where changes are more likely to have occurred to habitat structure (Bailey *et al.*, 2010). It may also be explained by the sparrows moving to other gardens with a general upsurge and proliferation of bird feeders in local gardens. It is hoped that the numbers will return to normal once construction of new houses on the site is completed.

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	200-1	2001-2	2002-3	2003-4	2004-5	2005-6	2006-7	2007-8	2008-9	2009-10	Average
Mar	21	21	31	31	29	22	13	25	15	15	22.3
Apr	11	14	31	31	25	21	21	15	17	10	19.6
May	8	8	25	10	21	17	22	8	7	6	13.2
June	14	14	10	13	11	11	24	5	8	3	11.3
July	12	15	14	15	14	12	12	6	10	5	11.5
Aug	10	22	22	16	10	11	5	9	5	8	11.8
Sep	15	31	31	18	21	6	4	5	5	4	14.0
Oct	25	32	31	20	22	20	13	11	12	2	18.8
Nov	27	33	30	23	21	25	20	14	15	1	20.9
Dec	12	32	34	25	25	25	21	21	24	8	22.7
Jan	16	19	33	31	20	26	25	21	15	7	21.3
Feb	21	25	23	28	21	27	20	19	15	6	20.5
Average	16.0	22.2	26.3	21.8	20.0	18.6	16.7	13.3	12.3	6.3	17.3

Table 1. Counts of house sparrows (*Passer domesticus*) at an Uddingston garden from 2000-10.

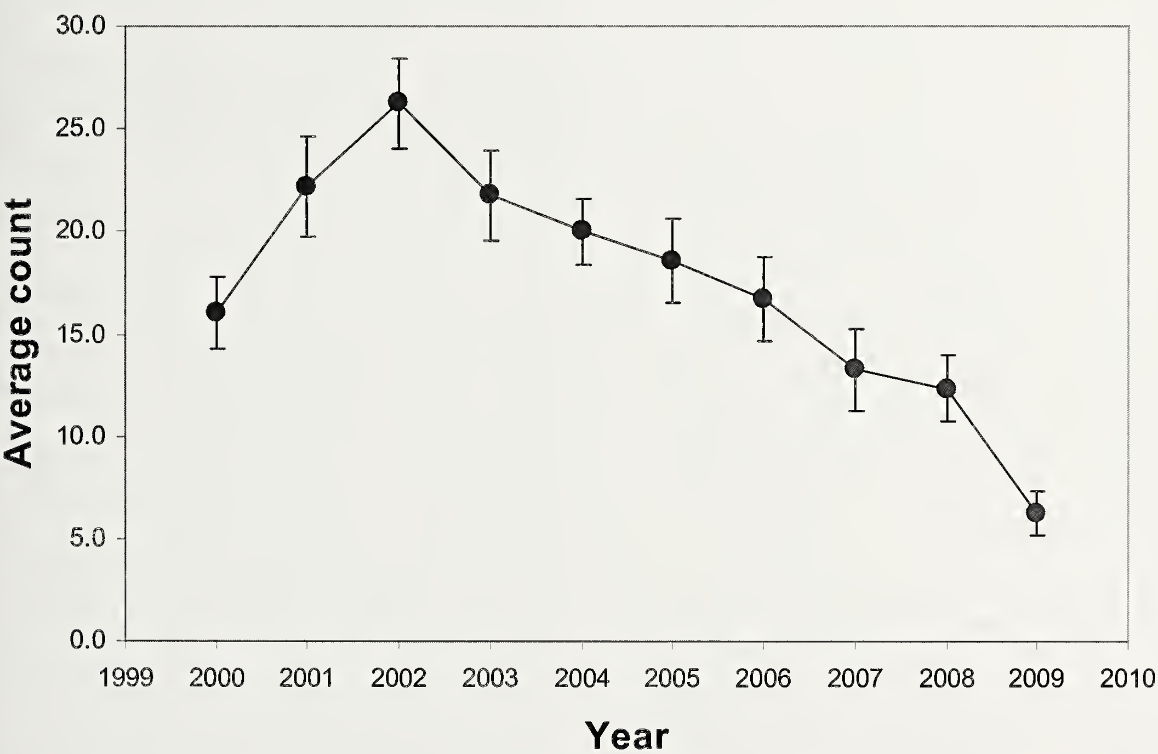

Fig 1. The average count (± standard error) of house sparrows (*Passer domesticus*) at an Uddingston garden from 2000-10.

North American signal crayfish, *Pacifastacus leniusculus* (Dana) in the River Kelvin, Glasgow

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The invasive, non-native North American signal crayfish (*Pacifastacus leniusculus* Dana) was first recorded from Scotland in 1995 (Maitland 1996) and has since colonised at least 174km of river length in 13 catchments and several standing waters (Gladman *et al.* 2009; Sinclair, 2010). The species has an expanding population in the upper River Clyde and its tributaries, where it has been present since at least 1989 (Trudgill, 2000; Maitland *et al.*, 2001). The continued spread of signal crayfish in Scotland is of concern because it presents a significant risk to native biodiversity and for that reason was included in the Species Action Framework for targeted action for five years from 2007 (SNH, 2007).

A signal crayfish was caught by Mr David Scobbie in the River Kelvin at Glasgow University Science Park/Veterinary School (NGR: NS 55321 70494 – Fig. 1) on 3 August 2010 while fishing for trout using earthworms as bait. The adult female specimen was examined alive by the authors on 4 August 2010 (carapace length: 52.9 mm). On the nights of 4 and 5 August 2010, five Swedish trappy traps* were baited with salmon-flavoured cat food and set in the immediate locality. During the second night, two adult males (carapace lengths: 53.8 mm and 55.4 mm – Fig. 2) were captured, confirming the occurrence of an established crayfish population.

Further investigations are necessary to assess the geographical extent and size of the Kelvin crayfish population. The capture of large adults suggests that signal crayfish may have inhabited this river for several years. Swedish trappy traps are biased towards catching large adults and so additional sampling using fine-meshed traps or electrofishing is required to confirm the presence of other age classes. Given the large size of the River Kelvin at the capture site (Fig. 1), there appears little hope of cost-effective eradication or containment but this must be assessed objectively.

Fig.1. Looking downstream from the sample site, River Kelvin

Fig. 2. North American signal crayfish from the River Kelvin

This is the first record of crayfish from the River Kelvin and is significant because it is at least 65km from the nearest known record from the River Clyde (Clyde River Foundation, unpublished data) and considerably further following the line of hydraulic continuity, which also passes through a stretch of brackish water. The origin of the Kelvin crayfish therefore remains enigmatic. Among the possibilities, however, are deliberate human introduction; inadvertent human introduction (for example on clothing or angling equipment previously used in crayfish-affected areas); transfer by birds or other animals; or introduction by colonisation from hitherto unrecorded populations in water bodies adjacent to the river. It is extremely unlikely that the definitive route of entry to the Kelvin will be established.

The presence of crayfish in the Kelvin system also raises the possibility of cross-watershed migration to other river catchments and this is already considered a real threat at the Clyde-Annan watershed in the upper Clyde (Yeomans *et al.* 2010). The close proximity of the headwaters of some Kelvin tributaries (eg. the Allander and Glazert Waters) to those of the Endrick

system (Loch Lomond catchment) mean that vigilance is required to protect the natural heritage of Loch Lomond and its rivers from the ingress of North American signal crayfish.

We thank David Scobbie for access to the first specimen and the committee and members of the River Kelvin Angling Association for their support. The three specimens referred to in this note have been deposited in the Hunterian Museum Zoology Section, University of Glasgow [Voucher Numbers 140 273 (female) and 140274 (males)].

*Trapping was conducted under licence from the Scottish Government. It is illegal to trap, be in possession of or transport live signal crayfish without a licence.

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The elusive planktonic freshwater chrysophyte *Bitrichia longispina*: a first record for Scottish lochs and comparison with the commoner species, *Bitrichia chodatii*

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Chrysophyte or golden algae are greatly under-recorded in the UK, despite their widespread dominance across nutrient-poor lakes in Northern Europe (Ptacnik *et al.*, 2008). They are particularly good indicators of oligotrophic waters as, unusually for algae, chrysophytes can supplement their nutrient supply through consumption of bacteria. It is unclear whether the apparent scarcity of chrysophyte algae is due to limited taxonomic understanding of this group or because the UK lake environment is different (e.g. prevailing Atlantic climate or impacted waters) and consequently confines their distribution.

The only known previous UK record of the planktonic chrysophyte *Bitrichia longispina* (J.W.G. Lund) Bourrelly, is from Wise E'en Tarn in Cumbria the English Lake District by the renowned phycologist Dr J.W.G. Lund, more than 60 years ago (Lund, 1949). Until now, there have been no subsequent documented records of this chrysophyte in the UK since the original finding (Kristiansen, 2002).

Bitrichia longispina therefore appears to be somewhat a rather elusive chrysophyte compared to its closely related species, *Bitrichia chodatii* (Reverdin) Chodat, which exhibits a widespread distribution pattern in Scottish freshwater lochs.

The Scottish Environment Protection Agency (SEPA) monitors the water quality of freshwater lochs as part of its obligation under the EU Water Framework Directive (European Commission, 2000). Freshwater phytoplankton communities are important indicators of the biointegrity of standing waters and are therefore used by SEPA to assess the ecological status of around 80 lochs in Scotland. Loch samples are collected at least three times a year for phytoplankton during the summer months, from July to September. Sub-samples of phytoplankton (preserved in Lugol's iodine) are examined using an inverted microscope and analysed according to standard procedures with counts of approximately 400 individuals (Brierley *et al.*, 2007; CEN, 2004 & 2008).

Small numbers (e.g. 5-10 cells per 100 ml sub-sample) of *Bitrichia longispina* were found in phytoplankton samples collected from Loch Langavat during the summer months of 2009. Loch Langavat (Scottish Gaelic: Langabhat) occupies an area of 1.43 km^2 aeross the Isle of Harris in the Outer Hebrides of Scotland (NGR: NG 046 897). It is relatively shallow (c. 5 m) and oligo-mesotrophic (annual mean total phosphorus (TP) concentration ranged from 7 to 13.6 μg L^{-1}, over 2007-09) in character. Recent palaeolimnological evidence using fossil diatoms has shown that the loch is slightly impacted by nutrient enrichment and no longer considered to be of pristine reference condition (Bennion *et al.*, 2004). Currently, this is the only monitored Scottish loch in which *Bitrichia longispina* is known to occur. However, work will continue to determine whether any other lochs in Scotland support this rather elusive chrysophyte. In contrast, the related species *Bitrichia chodatii* is commonly found in many Scottish lochs.

Bitrichia longispina has been mostly documented from water bodies in the Czech Republic (Juris, 1967; Kitner & Poulíčková, 2003), though further records may exist in the WISER phytoplankton database. Although generally rare, there are some reports of the chrysophyte from other European waters (Bourrelly, 1957; Starmach, 1985), and even Alaska (Hilliard, 1966). Together, these findings suggest that *B. longispina* preferentially occurs in relatively low nutrient waters. Accounts of *Bitrichia chodatii* are often from oligotrophic habitats (e.g. Hilliard, 1966; Brettum & Halvorsen, 2004), though the species is known also to occur in waters of varying quality and colouration (e.g. Juris, 1967; Lepistö *et al.*, 2004). This appears to fit in with the apparent widespread distribution of *B. chodatii*, though its prevalence in relation to environmental factors remains to be explored in Scottish lochs.

For some flagellated algae like chrysophytes, the structure of a cell's protective casing or 'lorica' is often used to differentiate between taxa, and this tactic usually applies to members of the *Bitrichia* genus (Menezes & Huszar, 1997). However, the loricae belonging to *Bitrichia chodatii* and *B. longispina* can appear similarly ovoid, leading to possible misidentification. In this case, spine morphology is a more useful taxonomic characteristic for distinguishing these two species from each other. The key diagnostic feature of *Bitrichia longispina* (Figs 1a, 1b) is that it possesses long and straight terminal spines, between 53-65 μm, and of relatively equal length (Lund, 1949; Juris, 1967; Kristiansen, 2002). The variability in spine length may be evidence of a functional response to the environment (e.g. trait conveying resistance to sinking or grazing) and is worthy of future research. By comparison, *Bitrichia chodatii* (Figs 2a, 2b) has shorter, usually <40 μm, and curved terminal spines of unequal length (Lund, 1949; Juris, 1967; Kristiansen, 2002).

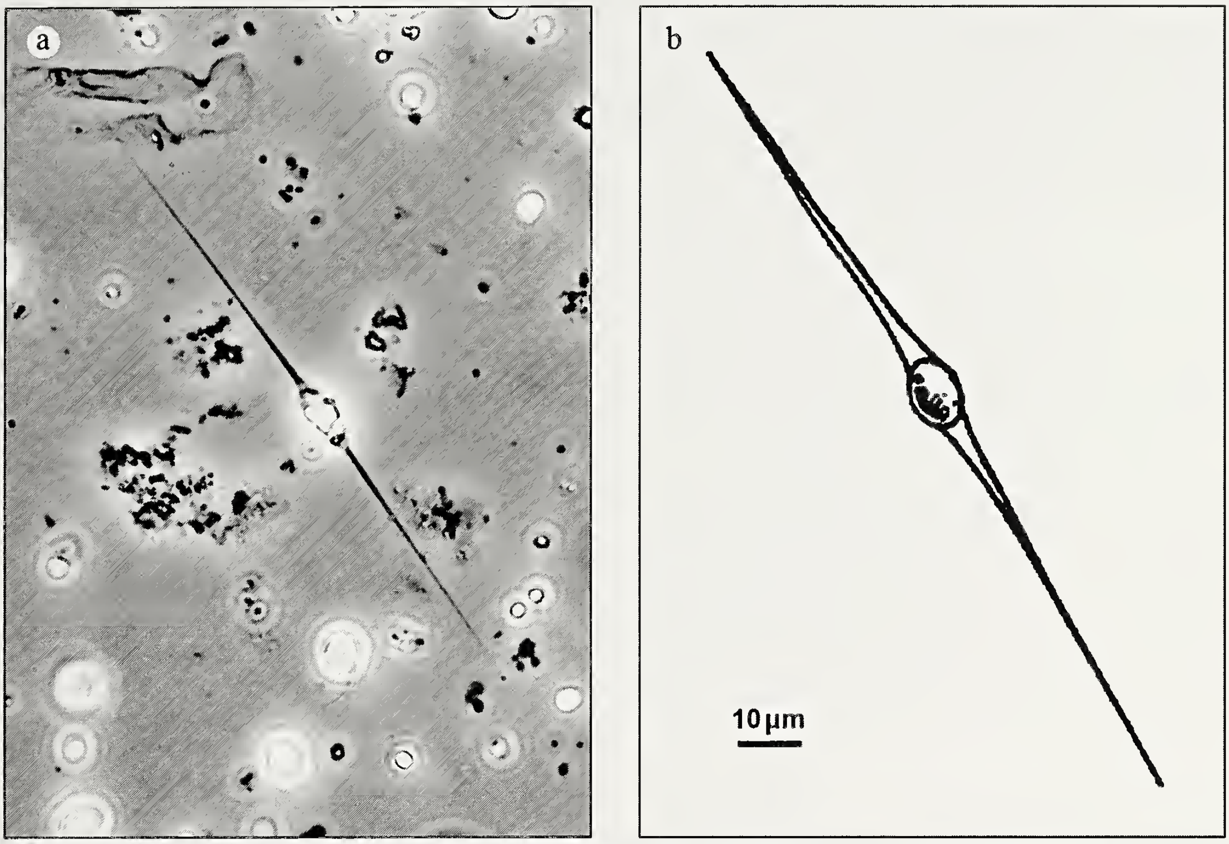

Fig. 1. (a) Photo-micrograph of *Bitrichia longispina,* (b) Illustration of *Bitrichia longispina* (x630 magnification) in Lugol's preserved sample.

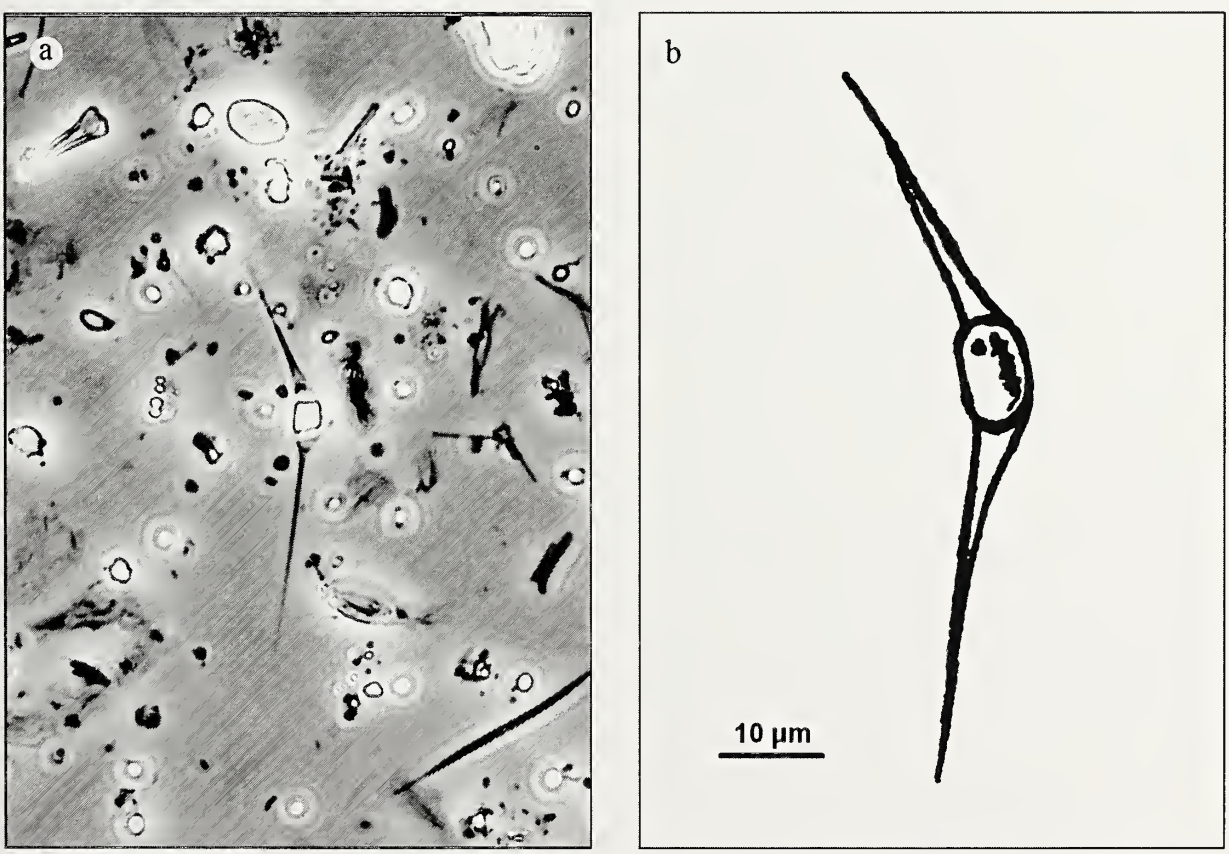

Fig. 2. (a) Photomicrograph of *Bitrichia chodatii,* (b) Illustration of *Bitrichia chodatii* (x630 magnifation) in Lugol's preserved sample.

More in-depth research would improve our knowledge of the seemingly different ecology of the two *Bitrichia* species. Such information would not only help resolve the limited distribution of *B. longispina*, but could also contribute to a better understanding of planktonic bioindicator species. This could improve European environment agencies' interpretations of the water quality status of our precious freshwater lake ecosystems.

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ABSTRACTS
Darwin and Evolution Today

The Department of Adult and Continuing Education (DACE) together with the Glasgow Natural History Society (GNHS) and the Division of Ecology and Evolutionary Biology (DEEB) hosted a day of public talks on 14 February 2009 to celebrate the bicentennial of Charles Darwin's birth. Over 100 members of the public, staff and students attended. This event examined how Darwin's ideas on evolution are being explored today and it was an opportunity for researchers to engage the public with the science behind evolution.

Dr. Dominic McCafferty (DACE) opened the day with a look at how Darwin's early student days in Edinburgh, his observations of natural history in Scotland and his connections with Scottish scientists influenced his development as a naturalist. Speakers were tasked with taking a chapter from the first edition of *The Origin of Species* (published in 1859) and evaluating it from a modern perspective. Dr. Colin Adams (DEEB and Scottish Centre for Ecology and the Natural Environment, SCENE) showed how freshwater fish populations in Scotland demonstrated many of the same patterns of diversity as Darwin observed in Galapagos finches. Using his own research on the reproductive behaviour of birds Dr. Ruedi Nager (DEEB) examined the trade-offs through which natural selection operates and Dr. Barbara Mable (DEEB) reported changing views on animal hybridisation due to the rapid advances in molecular techniques. Emeritus Professor Mike Hansell (DEEB) focused on perceived problems in explaining social insect behaviours under models of individual-based natural selection. The audience were then treated to a fascinating tour of the geological record by Dr. Alan Owen (Department of Geographical and Earth Sciences) who outlined how our understanding of fossil evidence has progressed since Darwin's time. The final talk of the day was given by Prof. Roger Downie (DEEB), who discussed changing views on embryology and the degree to which early developmental stages reflect ancestral relationships amongst species. Presented here are abstracts from presentations given on the day.

Darwin in Scotland

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At the age of sixteen Charles Darwin entered the University of Edinburgh in 1825 to study medicine. He never completed his medical studies but did take to natural history. During the winter of 1826 he collected marine specimens from the shores of the Firth of Forth, with zoologist Robert Grant. While at Edinburgh Darwin trawled with the oyster fishermen of Newhaven for specimens and made a presentation on two observations of sea-shore animals to the Plinian Society in 1826.

Darwin went on to take a B.A at the University of Cambridge and then embarked on his five year voyage on H.M.S. Beagle. Darwin read *Principles of Geology* (1830) by the Scottish born geologist Charles Lyell which was to strongly influence his observations and thoughts on geological formations and species distributions. Some years later in June 1838 Charles Darwin went on a three week geological field trip to Scotland. He traveled by steam packet from Liverpool to Glasgow, on to Edinburgh to visit Salisbury Crags, via Loch Leven and then to Glen Roy to study the Parallel Roads. In 1855 Darwin also attended the British Association meeting at Glasgow on 1st September 1855. Darwin was undoubtedly influenced by a number of scientists associated with Scotland, including his close friend Joseph Hooker, one of the most important nineteenth century botanists.

There are a number of collections associated with Darwin from the Glasgow Museums Resource Centre, Kelvingrove Art Gallery and Museum and The Hunterian Museum, University of Glasgow. In recent years Darwin has been appropriately recognised in Scotland. The Darwin Mounds discovered 180 km off the NW coast of Scotland in 1998 were named after the research vessel Charles Darwin. These deep sea sand volcanoes support cold water coral communities that are now internationally protected. The University of Edinburgh marked its association with Darwin by naming one of its main biology buildings the Darwin Building and by erecting a plaque at the Royal Museum in 2002 to mark the site of his student lodgings. There is no doubt that Darwin left a lasting legacy on the way we think about evolution and biology in the 21st century. Although Darwin's ideas

on evolution are still not universally accepted, evolution is taught in schools throughout the country and most Scottish universities have strong research teams investigating evolutionary processes. A full article on this subject can be found at: McCafferty, D.J. 2009. Editorial: Darwin in Scotland. The Glasgow Naturalist 25 (2) 1-3.

Phenotypic diversity, the raw material for natural selection

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Of Darwin's four requirements for Natural Selection, his "variation in traits" is the one that that provides the diversity of phenotypes upon which selection pressures can act in different directions or with different strengths on different individuals expressing this variation. Thus in populations in the wild, diversity of phenotype provides the raw material for selection. But how does this variation arise in natural populations and what does the route and speed at which it arises tell us about the process of evolutionary change? Over the last few years, I and colleagues from SCENE and our collaborators in laboratories across North America and northern Europe have been interested in evolutionary changes that seem to be occurring in freshwater fish living in previously glaciated lakes. A number of fish species are showing very rapid evolutionary change at a pace that is much faster than would be expected by traditional models. One species in particular, the Arctic charr, *Salvelinus alpinus*, exhibits a very high degree of phenotypic diversity across its range. In Scotland for example, there are 200 populations most of which show very significant divergence from each other in elements of their phenotype which has a strong functional role in their ecology. In 7 places in Scotland, polymorphisms, discrete phenotypic groups, living in the same lake have been recorded. For 3 of 5 for which we have information, we know that these discrete forms have diverged *in situ* since the last ice age, that is within the last 8000 years. This species has provided a useful model to test questions about the speed that phenotypic variation can arise. Field and experimental observations and manipulations have shown that charr have the ability to express a wide range of phenotypes from a single gene-pool in a process called phenotypic plasticity. This species (but others such as the 3 spined stickleback and whitefish species can do this also) has the ability to express the variation in phenotype upon which natural selection can then act, through developmental processes in response to exposure to different environments, before any genetic change. They can thus kick-start the evolutionary process which can then result in some phenotypes being favoured above others; that is, natural selection. We know from work in Scotland that different populations of charr are at different stages in the evolutionary process that ultimately leads to speciation. Recent taxonomic reviews of freshwater fish in Europe concluded that evolutionary divergence had progressed sufficiently far in some places, notable Loch Rannoch for the charr in these lochs to be regarded as full species. At other sites it is clear that the evolutionary process is at an earlier stage. Thus the dynamic processes of evolution are not only inherited from times past, they are active and developing and at speed in Scottish species and, if the natural habitats that are supporting these processes are given sufficient protection they will continue to provide wondrous insights into processes of evolution that we are still far from fully understanding.

Darwin and the evolution of bargains

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Darwin's theory of evolution has become one of the cornerstones of biology. This is also true for the discipline of behavioural ecology where Darwin's ideas play an important role to address ultimate questions about behaviour. Behavioural ecology employs techniques that are borrowed from evolutionary biology to explain patterns of behaviour and one of these key concepts is *optimisation*, where individuals are assumed to behave in a way that offers the greatest return given all the different factors and constraints facing the organism. The optimal solution may involve compromises or trade-offs that can hold back change and Darwin has recognised this. For example being the best at reproducing and being the best at surviving are often very different things and the behaviour and physiology of individuals are often telling compromises. Darwin's most important idea, natural selection, explains that evolution works by competition between individuals, or survival of the fittest. It is only the most competitive individuals that will be able to gain a sufficient share of these resources to survive and reproduce successfully. Darwin also saw many parallels to this in the competition between growing organs as they develop inside an organism and compete with each other for limited resources, i.e. the success of one organ comes at the expense of another. Today we usually refer to them as resource allocation trade-offs. Although trade-off has a modern ring and is important to the optimisation concept in behavioural ecology, the concept traces back to Darwin and his concept of '*material compensation*', also sometimes called *balancement*. Because in the wild different individuals hold widely varying quantities of resources, negative correlations as evidence of trade-offs can be overridden by positive correlations. The rigorous demonstration of such resource allocation trade offs requires experimental work. This has been illustrated in this talk with experiments on the optimal clutch size in a wild bird.

David Lack (1947) argued that birds should lay a clutch that maximises productivity. This hypothesis has been tested by many field studies and from those studies a consistent pattern emerged that birds laid fewer eggs than the clutch size that would have produced the most independent young (Monaghan & Nager 1997). Field experiments on lesser black-backed gulls *Larus fuscus* have shown that egg formation is costly and these costs would need to be taken in consideration when assessing the most productive clutch size in gulls. Manipulation of the number of eggs females laid showed that increased egg production reduces the parental ability to raise young (Monaghan et al. 1998) and lay high-quality eggs (Nager et al. 2000a). Moreover, it was the male offspring that were particularly vulnerable to poor parental rearing condition (Nager et al. 2000b) and egg quality (Nager et al. 1999). Darwin's idea of natural selection predicts that in this case parents should preferentially invest into the more productive sex, female offspring in this case. Darwin however favoured the idea of equal proportion of male and female offspring (Darwin 1871). For the lesser black-backed gull it was indeed found that birds that were made to produce more eggs than they would normally lay had an excess of female offspring (Nager et al. 1999). The underlying mechanism how birds change the sex of their offspring is not yet known.

This illustrates nicely the power of Darwin's idea on natural selection and trade-offs that still nowadays offers elegant predictions and this concept is still used today to explain patterns that on first sight may appear non-adaptive.

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Hybridisation and other things that animals aren't supposed to do

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The appeal of the biological species concept is that it provides a simple and testable criterion by which to classify individuals into species. Although there are a number of variants to the original definition, the basic idea is that reproductive isolation is the critical defining feature of a species. Under the strictest version of this view, viable hybrids between species should thus be a conceptual impossibility. Although this basic type of concept was also prevalent in the time of Charles Darwin, he was fascinated by hybridisation (although he was concerned more with relative fertility of different types of crosses than he was with what they might say about species definitions). His experimental data on crosses in plants and domestic animals convinced him that inability to cross is often completely unrelated to "systematic affinity". Nevertheless, he was perplexed that whereas hybridisation could create individuals that were superior to their parental types, this was often rendered an evolutionary dead end by sterility of even very vigorous hybrid individuals. He was thus left with an overall negative view of the role of hybrids in speciation and evolution. The birth of Mendelian genetics opened the opportunity to re-evaluate the consequences and benefits of hybridization. Plant biologists have long accepted that plants have extraordinary flexibility in their reproductive systems and that hybridisation, while inconvenient for defining independent lineages, is an important creative evolutionary force. Animals have not been given as much credit for reproductive flexibility and animal biologists have been more reluctant to deviate from the 'hybrids as mongrels' view. However, this is not a realistic view in the post-genomic era. It is already apparent that dramatic genomic changes such as whole genome duplication are much more frequent in animal evolution than previously considered and the tools now exist to document the extent of historical hybridisation events as well. Already, new techniques are revealing that previous rules about genetic compatibility are too rigid to explain observed patterns and that our old views about hybridisation were likely a bit naïve. This talk was focused on outlining how continuing developments in technology have changed our understanding of genetic compatibility and hybridisation, drawing examples predominantly from amphibians. The talk concluded by emphasising that the predictions of innovators like Darwin and Mendel, although often under-appreciated in their own time, have held up to subsequent technological advances and we should keep an open mind to the new ideas and innovations that will be suggested in the post-genomic era.

Instinct and Darwin's 'One special difficulty'

Mike Hansell

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Chapter 7 of the first edition of Charles Darwin's *The Origin of Species* is entitled simply '*Instinct*'. The book overall is dominated by the consideration of the form or structure of animals and plants, however, Darwin seems to have felt that, to make the strongest possible case for the power of his theory of natural selection, he needed to say something about the evolution of behaviour as well as that of anatomy. There seems to have been a particular reason why Darwin chose to write about the evolution of behaviour over and above simply wanting to give the broadest possible relevance to his thesis. It was that he saw in the behaviour of ants a serious potential weakness to his argument and that it was essential that he faced it and tried to account for it. So serious did he regard this problem that he wrote:

'*I …… will confine myself to one special difficulty, which at first appeared to me insuperable, and actually fatal to my whole theory.*' Chapter 7 of The Origin of Species sets out specifically to tackle difficult cases of adaptive animal behaviour but in particular the *'one special difficulty'*.

Darwin's approach to writing about the evolution of behaviour, closely matches the pattern of reasoning and associated evidence that he adopts in the chapters concerning anatomy. He seeks to establish that behaviour is inherited, that it varies between individuals of the same species, and that we can account for evolutionary changes in behaviour in terms of a long series of small changes brought about by selection over many generations. To us this might seem a fairly straight forward ambition but, as Darwin admits, there was in his day very little by way of even descriptive studies on animal behaviour, on top of which he also faced the problem that afflicts the whole of the book; he had no idea how any character, behavioural or anatomical, was passed from one generation to the next. It was, of course, not until the end of the 19th century, too late for Darwin, that Mendel's work on the inheritance of colour in pea flowers became more widely known by the scientific community, and the development of the study of animal behaviour as a science was definitely a 20th century affair. It was not until 1973 that Niko Tinbergen, Conrad Lorenz and Carl von Frisch, at the end of their careers, were awarded the Nobel Prize for Physiology as pioneering founders of the science of animal behaviour. The focus the work of Tinbergen and Lorenz was indeed in the definition and understanding of instinct. The study of the genetics of behaviour was really only getting started in the 1960s, nearly a hundred years after Mendel's studies on plants. In that context Darwin's efforts in tackling the issue of instinct is courageous.

In his chapter on instinct, Darwin chooses a number of cases, nearly all relating to insects, where extremely specialised adaptations challenge the notion that they could have been arrived at by small incremental changes over many generations. In this context he deals rather effectively with the evolution of the beautiful regular geometry of the honeybee wax comb and with the behaviour of slave making that in some ant species is so extreme that the slave makers are even totally dependent upon the ant slave species to bring them food. But that still leaves Darwin's 'special difficulty'. Darwin continues from '*…that appeared to me insuperable and actually fatal to my whole theory.*' To say: *'I allude to the neuters or sterile females in insect communities.'* You can readily see the problem; how can the character of being sterile be passed on to the next generation. But it is interesting to see that to Darwin there are actually two problems, of which he sees the evolution of sterile individuals as being the lesser. The '*climax of the difficulty*' according to Darwin is that in some ant species there is not simply one sterile caste but several, often highly specialised and dramatically different from one another. Where is the evidence of all the intermediate stages that should have been passed through to achieve this?

Darwin's solution to the problem of the inheritance of sterility is interesting, and still a very live issue today. He says: '*This difficulty, though appearing insuperable, is lessened or, as I believe disappears, when it is remembered that selection may be applied to the family, as well as to the individual.*' The whole argument of the level at which natural selection operates has seen repeated changes in emphasis over time. In the 1950's so-called 'group selection' achieved some popularity. In 1964, W D Hamilton wrote two theoretical papers that demonstrated that the behaviour of helping close relatives could evolve through selection at the level of the individual. But some feel that selection at higher levels are a significant feature of evolution. E O Wilson, with a distinguished career of research on ant social behaviour behind him is a strong advocate of colony level selection in these creatures. He and Bert Holldobler have just published a book under the title '*The Superorganism*', which promotes this point of view.

What then of the '*climax*' of Darwin's difficulty? His own observations, now confirmed by modern research, resolved this problem too. Yes, there are in some ant species two or more worker castes that are dramatically different from each other both in body form and behaviour. Nearly every worker in the colony is clearly recognisable as of one caste or another, however, there are also a small number that are not. Together these 'misfits' represent all the small steps that would have been needed to evolve one caste from another. Darwin had found the evidence and reasoning to neutralise the '*special difficulty*'.

The geological record of life on Earth

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All but one of the periods of the Phanerozoic, that part of geological time with a rich fossil record, had been named prior to 1859 when Charles Darwin provided an explanation for the changes in fossil content on which those divisions were based – natural selection. Since then, a detailed record of the originations and extinctions of fossil species has been amassed and underpins a highly refined, globally applicable, relative time scale for the Phanerozoic to which dating based on the decay of radioactive isotopes now provides an absolute time scale. It is clear that Darwin accepted the vastness of geological time that radiometric dating has now quantified. In contrast, he found no evidence to suggest that the positions of the oceans and continents were anything other than fixed in their present positions throughout the Phanerozoic. The recognition of plate tectonics in the 1960s, as revolutionary and unifying a theory in geology as was Darwin's in biology, now provides a highly dynamic framework for the understanding of the fossil record. Darwin's concern about differences in some fossil faunas between what are now closely situated regions can be explained not by large gaps in the record but by changing biogeographical patterns caused by the movement of continents and the opening and closing of oceans. Whilst the temporal refinement of evolutionary changes shown by fossils is fairly coarse, Darwin was in many ways overly pessimistic about the imperfection of the fossil record. Examples of evolutionary changes and relationships at the species level abound and the major evolutionary transitions have become much clearer; recent work on the early land plants and on the development of tetrapods from fish are notable examples. The fossil record is strongly biased in favour of organisms with shells or mineralised skeletons but many examples of the preservation of soft-bodied organisms have now been documented. Moreover, the fossil record is now recognised to extend back considerably further than the lowest fossiliferous strata known to Darwin. Small shelly fossils mark the onset of biomineralisation at about 545 Ma (million years) ago following the appearance of metazoans in the late Precambrian currently indicated both by fossils and molecular clock data to have been at about 600 Ma. Prior to that, life was at the unicellular level with eukaryotes appearing at about 1400 Ma and prokaryotes extending back to at least 3500 Ma. Photosynthesis by early prokaryotes caused fundamental changes in the chemistry of the Earth's surface, including the appearance of oxygen in the atmosphere. Evolution has not only led to the diversity of organisms seen today but also to the physical environment in which they live.

Embryos and ancestors: the relationship between evolution and development, from the Biogenetic Law to modern Evo-Devo

Roger Downie

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Chapter 14 of the 6th edition (1872) of the *Origin* included Darwin's thoughts on the evidence from embryology. This drew on von Baer's Laws of Embryology (1828), though von Baer was a committed anti-evolutionist till his death (1876). Darwin was influenced by Haeckel's interpretation, laid down in the Biogenetic Law, that evolution involved the addition of new adult stages to previous ones, allowing phylogeny to be deduced from developmental sequences. Haeckel and Darwin both thought in Lamarckian terms – that new features would be added mainly through their usefulness to adult organisms – for want of a better theory of heredity. This idea lost its force once Mendel's findings were understood. Another blow to the Biogenetic Law was neoteny: new forms could result from the loss of ancestral adult features, so that phylogeny could not be followed reliably from developmental sequences.

Embryology played no part in the Neo-Darwinian synthesis (1920-40) but its importance to evolution was resurrected in 1977 by Gould's *Ontogeny and Phylogeny* and took new life from the findings of molecular genetics (1990s onwards): the body plans of all animals are laid down by the expression patterns of a set of highly conserved homologous genes, fully according with Darwin's views on descent with modification. We are now in a position to investigate in detail how alterations in developmental regulating genes can result in altered body forms. Two concepts explored are a) heterochrony – the importance of changes in developmental timing b) constraint: the ways in which the developmental system may limit evolutionary changes.

BOOK REVIEWS

A Field Guide to the Geology of Madeira

C. J. Burton and J. G. MacDonald.

The Geological Society of Glasgow, 2008. A5 format, 120 pages, softback, 24 full colour plaes, numerous maps and line drawings. ISBN 978-0-902892-11-8, £10.

Many years ago I was on holiday in Mallorca and had a geology paper on the area. The paper was very erudite but unhelpful, as far as I was concerned! In contrast, this excellent, well produced and readable little book is informative and user friendly.

The book provides a summary of the geology and geography of the island, which was formed by volcanic eruptions under the Atlantic. The island archipelago emerged approximately 20 million years ago. The vegetation is due to seeds having been being transported by wind and birds to the islands.

The spectacular landscape is in the form of a lava plateau dissected by ravines and steep narrow valleys. The stratigraphy is complex. A series of cycles of volcanic activity, dating from the Miocene to the Quaternary, have been acted upon by uplift, tilting, erosion and sedimentation. The highest point on the island is the Pico Ruivo (1862m) and the coastline is formed by steep sea cliffs which rise to 633m, which makes them some of Europe's highest.

The book describes seven excursions to the geological highlights on the island. Three of the excursions, which are of an introductory nature are based in the Funchal area, the Pico Arieiro area and the Ribeira Brava location. The four additional excursions give a more detailed understanding of the island geology and are to a more advanced level. They are to the Sao Lourenco Peninsula, Porto da Cruz, the Valley of Sao Vicente and to the Boca da Encumeado

For the first time traveller to Madeira there are interesting glossaries – not only of geological terms, but of Portuguese geographical and geological terms as well as help with the pronunciation.

I am looking forward to attending an excursion to Madeira led by the authors - sitting in the sunshine, tasting the Madeira wine and listening to the authors explaining the fascinating story of the Geology of Madeira.

Ian C. McCallum

The Emerald Planet: How plants changed Earth's history

David Beerling

Oxford University Press, Oxford, 2007 (hardback), 2008 (paperback). 288 pages with black & white photographs and illustrations. ISBN 978-0-19-280602-4 (hardback), £14.99, 978-0-19-954814-9 (paperback), £8.99.

David Beerling is Professor of the new science of Palaeoclimatology at the University of Sheffield and has written this discussion of the interaction between plant evolution and climate change for the general reader. Rather than reflecting changes in environmental conditions, he argues that plants have played a major role in determining them. Taking the last 500 million years or so as his timescale, the author blends plant morphology, physiology and recent work in genetics, with geological evidence for the changing composition of the atmosphere and then liberally spices his synthesis with fascinating anecdotes about the scientists who provided clues to the major role that plants have played in shaping the global environment.

Each chapter (there are nine) explores a different hypothesis and is organised along the geological timeline (illustrated diagrammatically in Chapter one). Beering's themes include the thermostatic control of global climate driven by the Earth's molten core; fossil leaves that "breathalyse" the ancient atmosphere for carbon dioxide content; and evolving plant life speeding the rates of rock weathering. As photosynthesis removed carbon from the atmosphere plants generated changes that had far reaching consequences. And that is only chapter 2.

Each chapter starts with a short summary allowing one to select from this panoply the topics that are of particular interest to the reader. Chapter 3 "Oxygen and the lost world of giants" contains a wealth of evidence for the increase of oxygen levels to over 30% in the Carboniferous and subsequent fall to 15% by the close of the Permian. Chapter 4, "An ancient ozone catastrophe?", starts with a digression dealing with the tradition of "wranglers" of the University of Cambridge; continues with the naming of ozone (in 1839), the discovery of the ozone layer and the subsequent discovery of its loss over the Antarctic. This is interesting enough; however Beerling goes on to discuss the hypothesis, supported by evidence from mutated fossil spores, that a depletion of the ozone layer caused the mass extinction at the end of the Permian. Chapter 5 explores later extinctions of marine life which were accompanied by a rise in carbon dioxide levels and subsequent global warming allowing the success of dinosaurs over their competitors.

In later chapters Beering outlines the puzzle of the ancient deciduous forests that flourished in the polar areas, now covered by ice, but for most of the Earth's history considerably warmer and with long dark winters. Other greenhouse gases are discussed, with several positive feedback loops and a warning as to possible future consequences of altering the chemistry of the atmosphere.

There is more: rubisco, C3 plants (forests), C4 plants (savannahs), wildfire, molecular clocks, fossil teeth and charcoal sediments . . . . . if I can find a fault with this book it is that each subsequent chapter is so engrossing that it drives the author's previous deliberations from my head; but I will return to this book again.

Research cited throughout is supported by copious references and notes.

The comprehensive index should enable me to retrieve some of the half remembered ideas gleaned from a first reading of this extremely interesting book. I am very glad to have seen the photographs used as illustrations.

Lyn Dunachie

Freshwater Megaloptera and Neuroptera of Britain and Ireland – Keys to Adults and larvae and a review of their ecology
J. M. Elliott

Freshwater Biological Association, Ambleside, Scientific publication no 65, 2009.
71 pages, softback with black and white line drawings and two black and white photographic plates. ISBN 0-900386-77-0, £18.

This book will be an invaluable reference tool for researchers, ecologists, students and keen amateurs interested in freshwater ecology and freshwater insects. After 75 years of publishing the Freshwater Biological Association (the FBA) certainly know what they are doing. Whilst the authors change, the FBA style, format and content are instantly recognisable, with their trademark clarity and general accessibility. This volume is the fifth incarnation of this text since 1944, so there have been plenty of opportunities for refinement. J. M. Elliott has authored the last three editions; including the edition (4th) that preceded this one in 1996. The 4th edition was required to reflect the addition of the alderfly *Sialis nigripes* to the British list. There have been no such changes in the fauna since then; however, like many key entomological texts, the 1996 edition had gone out of print, so a revised alternative is very welcome.

Whilst there are 64 species of Megaloptera and Neuroptera (lacewings and their allies) currently recorded for Britain, the majority of these species are terrestrial; only 7 species are aquatic at some stage in their lives and consequently eligible to feature in this text. The species include three alderflies (*Sialis lutaria, S.fuliginosa* and *S.nigripes*), one osmylid (*Osmylus fulvicephalus*) and three sponge-fly (*Sisyra fuscata, S.dalii* and *S. terminalis*). Quite exceptionally for an entomological text, one is not bamboozled with biodiversity, but as the preface states, what these organisms lack in diversity they make up for in ecological importance.

The 71 pages are ample to key out the adults and larvae and to outline the current state of knowledge about the biology of each of the featured species. About half the book is devoted to a general introduction to the group and the keys: the other half covers the ecology and includes an extensive and comprehensive bibliography.

The introductory pages include a superficial outline of the general characters, classification, collection and preservation and a checklist including synonyms for the Megaloptera and Neuroptera. The keys are beautifully clear and punctuated with some excellent line drawings depicting key morphological characters, including the satisfyingly distinctive genitalia. The keys are as complete as they can be bearing in mind the current knowledge gaps. There is still no reliable way of distinguishing the females of the adult sponge-flies, or the larvae of *S. dalii* from other *Sisyra* spp. or any of the 1st and 2nd instar *Sialis* spp. larvae. An error exists in Fig. 1, where diagram B should refer to *Sisyra fuscata*, not the genus *Sialis*.

The ecology section is arranged by species and includes what is known about the global distribution, habitat requirements, anatomy and physiology, life-cycle, flight periods, emergence times, predators, prey, parasites, dietary preferences and behaviour of each species.

There are no British distribution maps or detailed geographical information provided for the majority of species, but then there's always the National Biodiversity Network gateway (http://data.nbn.org.uk). For the record, *S. terminalis* and *O. fulvicephalus* have virtually no records from Scotland to date and *S. dalii* has none at all, the remaining species are widely distributed.

The 'Collection and Preservation' section is very superficial and would be of little use as a guide. If you don't know how to set or preserve specimens, or need guidance on sourcing relevant entomological supplies, you will need to look elsewhere.

Jeanne Robinson

Woodlice and Waterlice (Isopoda: Oniscidea & Asellota) in Britain and Ireland
Steve Gregory

FSC Publications, Shrewsbury, 2009 on behalf of the Biological Records Centre. 176 pages, softback, 39 colour photos, 53 black and white maps. ISBN 978-0-9557672-8-9, £19.50.

The isopod survey scheme was launched in 1968. Formal recording of marine species did not last long, but recording of terrestrial species (woodlice) developed rapidly and a Provisional Atlas was published in 1976 followed in 1985 by Harding and Sutton's "Woodlice in Britain and Ireland" (WIBI). With maps occupying less than one third of its pages, WIBI was more than an atlas. It included accounts of habitat data and also descriptions of four species added to the British list since 1972.

Steve Gregory's new book goes further still. Britain's four freshwater isopods are now included - the familiar *Asellus aquaticus* and its relatives (waterlice) which were dealt with separately in the 1980s. Their inclusion should make information on the waterlice more accessible. On woodlice, the number of native or naturalised species has increased from 35 in WIBI to 40. Species accounts have been updated and expanded, and there are many colour photographs. There is a new section on biogeography and the welcome addition of brief accounts of our 12 "glasshouse aliens". Steve Gregory has done a very good job with an easy and clear style of writing. I have no doubt that, like the Provisional Atlas and WIBI, the book will stimulate wider interest in these fascinating invertebrates, and more recording.

My major grumble about the book concerns the map symbols used to distinguish records in different date ranges. Records between 1968 and 1982 are denoted by an open circle – a common enough symbol in this context, but in this case the circle comprises a very thin line which is easily overlooked, particularly in areas of the map where the background is a convoluted coastline, such as the west of Scotland. I should declare an interest here - many of my own records pre-date 1982 and are in those areas! I understand that this problem was identified at the proof stage and requests were made that it should be rectified, but this seems not to have been done. This book is the first of what the Biological Records Centre hopes will be a series of atlases to be published in partnership with the Field Studies Council. I hope that steps are taken to ensure the clarity of all symbols in these publications.

So what does this book mean for naturalists in Glasgow? It shows that there is plenty of scope for clarifying the distribution of a number of easily identified species (for identification see the excellent AIDGAP guide by Steve Hopkin). Here are two examples. *Porcellio spinicornis* is a good candidate for urban recording. It is often found in buildings, probably because it likes a good supply of lime and relatively dry conditions (it is not diagnostic of dilapidation or damp). In the Clyde area it has been found in tenement entries/stairways as well as the flats themselves, and in the roof spaces of churches and a University building. It is almost certainly common in the long established urban settings of the Clyde area, but that is not reflected in available records. There are also widespread records from rural areas of Scotland.

The Pill Woodlouse *Armadillidium vulgare* is particularly interesting as it is at the edge of its range hereabouts. Increased recording effort has led to a marked increase in the number of hectads with records of this species since WIBI and it is well worth hunting for additional sites. As a guide on where to look, I have found it recently at: two sites in Rothesay where several decades ago there were commercial greenhouses; at urban shoreline sites, e.g. in Largs and Helensburgh, where it seems plausible that garden debris has been dumped; at two new sites (new hectads too) adjacent to railways in the Clydebank area, prompted by re-finding the species at the sites reported by Susan Futter in the 1998 Glasgow Naturalist - one of her sites is also adjacent to a railway line. It is important to take care to discriminate the pill woodlouse from the pill millipede *Glomeris marginata*, but in our area that species is also interestingly close to the edge of its distribution so records are also valuable.

Get the book, get inspired and get recording!

Glyn Collis

Built by Animals: The natural history of animal architecture
Mike Hansell

Oxford University Press, Oxford, 2007. 256 pages, hardback with 25 halftones & line illustrations. Also available in paperback. ISBN 978-0-19-920556-1, £16.99

Wombats Detected from Space! So begins the second chapter of this delightful book where Mike Hansell tells us about the results of the building behaviour of the chunky, southern, hairy-nosed wombats of Australia whose complexes of tunnels deform the local arid desert environment such that the mounds created can be seen from space. This is to humorously illustrate his point that builders change their environment, not just for themselves but with consequences for others – something we humans should be all too aware of.

Mike Hansell is an internationally renowned expert on animal behaviour particularly their building behaviour. He has an extensive academic publication record including two editions of a student text book on the subject. Though he has also written numerous articles for non-specialist audiences plus advised on wildlife documentaries on the subject, this is his first full length book for a general audience. Fascinating facts abound but the book is much more than just descriptions of impressive animal construction feats - it is a proper account of the underlying biology and provides an easily comprehensible introduction to the scientific

disciplines of behaviour, ecology, evolution and adaptation.

Impressed by the parade of animal construction skills, an understandable if patronising response from the human perspective, is to think 'How do the clever little creatures do that?!'. Hansell goes to some lengths to stress the basic point that behaviour (i.e. the neural system plus its decision-making processes) when applied to building materials, results in animal architecture and no matter how humble or grand the resulting artefact, this simple rule underlies it. Complex animal structures, such as the nests of social insects – termites, bees, ants and wasps - further beg the question of how the individual animals work together to create them and Hansell addresses this fully in Chapter 4.

So, why do animals build? Predominantly to create homes for themselves or their offspring but also to trap food or for social display. Who does it? A wide selection of species across a number of phyla but amongst the vertebrates, the birds win hands (or should that be wings) down with the range of nests they construct. This is not to dismiss the efforts of mammals such as beavers, prairie dogs, or indeed the space age wombats mentioned above whose labours change the landscape on a human scale. Amongst the invertebrates it is the arthropods, particularly the insects, that shine as outstanding builders who achieve results, size for size, that rival our own achievements. The size and design of colonies of South American leafcutter ants – some containing up to eight million individuals – truly stagger the imagination. Another snippet to help adjust human self importance and one maybe very few of us think about - burrowing earthworms shift prodigious amounts of soil over their life times, e.g. they are gradually capable of burying archaeological remains. In an aside, Hansell tells us they were recently voted the animals we humans will most quickly perish without – competing against the embattled honey bee for this unwanted award.

What materials do animals build with? The list is long – some examples are plant materials of all kinds, mud, wood, sand grains, stones, saliva, faeces, wool, hair, feathers, silk and wax. Animals either generate the materials themselves or carefully select them from the environment. In general, animals do not have specially modified anatomy to make their structures. It is mainly limbs and mouthparts that do the job whilst maintaining their primary function, e.g. a bird's beak is first and foremost for food gathering but is also used to manipulate nesting material. The notable exception is for burrowers who live their lives underground and have to dig through hard substrate. The mole has flattened and strengthened front limbs shaped like shovels to excavate its tunnels.

Whereas structures used as homes and shelters predominate our thinking as to what constitutes an animal artefact, the other types of structures animals make are just as interesting. Trap building for food capture has a curious distribution in the animal kingdom. Surprisingly it appears to be confined to humans amongst the vertebrates, though more common amongst the invertebrates; spiders and their webs are the best known examples. Detailed descriptions of the biology of web building and other invertebrate trapping techniques are followed by discussion on the evolution of trap building. We join the author in puzzling over why no other vertebrates have evolved trap building.

Present evidence from hominid evolution studies identifies tool making and use as a key step on the road to modern *Homo sapiens* and our abilities to modify our environment. Tool use by non-humans is relatively rare, known in some primates, a few birds and some insects. Researchers are interested in a variety of questions here – including why tool use by non-humans is rare, how important is it to the animals where it occurs and if there is any indication that it is a sign of intelligence or foresight. After weighing the available evidence, Hansell is sceptical if open-minded on the latter. There are no clear answers yet and so more studies are needed.

The book concludes with a thought-provoking discourse on art and aesthetics arising out of a description of the remarkable bowers of bower birds and the nature of sexual selection. Do animals have a sense of beauty? What would it mean for their evolution and how might we find this out?

Hansell has written a typically eloquent account of a fascinating manifestation of animal life. He seamlessly weaves scientific method and understanding into the observations of nature that so clearly have inspired him. He is full of ideas and questions for future exploration. It is a pleasure to share these insights and enthusiasms. Any criticisms? None really. The usual plea for a more illustrations could be made as the subject clearly lends itself to visual imagery. That perhaps might be a future volume?

Maggie Reilly

Notebooks from New Guinea: field notes of a tropical biologist

Vojtech Novotny

Oxford University Press, Oxford, 2009. 256 pages, hardback with black & white drawings. ISBN 978-0-19-956165-0, £16.99

The jacket notes say Novotny is a leading tropical biologist and researches herbivorous insects. This had me a bit worried as I have not come across his name before, but this is possibly due to him being Czech, and writing often in that language, plus my own ignorance.

The book is translated expertly to retain the humour and flow the original clearly must possess. Essentially, it describes Papua New Guinea and its people, comparing their ideas and traditions with those of

Europe, tied together by stories and travels of the author. Work in PNG for considerable parts of 12 years or more, experiences arising from observing natural and human history and a considerable acquisition of anecdotes have been utilised. The numerous accounts can be either dipped into at random or read seamlessly from page one. This book is hugely entertaining and thought-provoking in equal proportions. Although it is tempting to air some of the verbal vignettes in detail it will suffice to give a few titles of sections – 'Would you care for an extra wife?', 'Thou shalt not eat thy neighbour', 'The dearest beer in the land' and 'Where monkeys defecate on people's heads'. Some of these relate to Czech traditions as much as Papuan ones but most have a combination or contrast of two cultures, not always as different from each other as one might at first think. There are three main divisions in the book, viz., 'Island of a thousand tongues', 'Old and new customs' and 'How to do science in Papua New Guinea'. There is an index and perhaps the most obvious test, to look up the words cargo and cult, reveals three page references. The main one is to a section called 'The cargo cult and the Czech cult of scholarship'.

All in all an interesting book for fire side or jungle side.

E. Geoffrey Hancock

The Emerald Planet: How plants changed Earth's history

David Beerling

Oxford University Press, Oxford, 2007 (hardback), 2008 (paperback). 288 pages with black & white photographs and illustrations. ISBN 978-0-19-280602-4 (hardback), £14.99, 978-0-19-954814-9 (paperback), £8.99.

David Beerling is Professor of the new science of Palaeoclimatology at the University of Sheffield and has written this discussion of the interaction between plant evolution and climate change for the general reader. Rather than reflecting changes in environmental conditions, he argues that plants have played a major role in determining them. Taking the last 500 million years or so as his timescale, the author blends plant morphology, physiology and recent work in genetics, with geological evidence for the changing composition of the atmosphere and then liberally spices his synthesis with fascinating anecdotes about the scientists who provided clues to the major role that plants have played in shaping the global environment.

Each chapter (there are nine) explores a different hypothesis and is organised along the geological timeline (illustrated diagrammatically in Chapter one). Beering's themes include the thermostatic control of global climate driven by the Earth's molten core; fossil leaves that "breathalyse" the ancient atmosphere for carbon dioxide content; and evolving plant life speeding the rates of rock weathering. As photosynthesis removed carbon from the atmosphere plants generated changes that had far reaching consequences. And that is only chapter 2.

Each chapter starts with a short summary allowing one to select from this panoply the topics that are of particular interest to the reader. Chapter 3 "Oxygen and the lost world of giants" contains a wealth of evidence for the increase of oxygen levels to over 30% in the Carboniferous and subsequent fall to 15% by the close of the Permian. Chapter 4, "An ancient ozone catastrophe?", starts with a digression dealing with the tradition of "wranglers" of the University of Cambridge; continues with the naming of ozone (in 1839), the discovery of the ozone layer and the subsequent discovery of its loss over the Antarctic. This is interesting enough; however Beerling goes on to discuss the hypothesis, supported by evidence from mutated fossil spores, that a depletion of the ozone layer caused the mass extinction at the end of the Permian. Chapter 5 explores later extinctions of marine life which were accompanied by a rise in carbon dioxide levels and subsequent global warming allowing the success of dinosaurs over their competitors.

In later chapters Beering outlines the puzzle of the ancient deciduous forests that flourished in the polar areas, now covered by ice, but for most of the Earth's history considerably warmer and with long dark winters. Other greenhouse gases are discussed, with several positive feedback loops and a warning as to possible future consequences of altering the chemistry of the atmosphere.

There is more: rubisco, C3 plants (forests), C4 plants (savannahs), wildfire, molecular clocks, fossil teeth and charcoal sediments . . . . . if I can find a fault with this book it is that each subsequent chapter is so engrossing that it drives the author's previous deliberations from my head; but I will return to this book again.

Research cited throughout is supported by copious references and notes.

The comprehensive index should enable me to retrieve some of the half remembered ideas gleaned from a first reading of this extremely interesting book. I am very glad to have seen the photographs used as illustrations.

Lyn Dunachie

Darwin 200: new books on Darwin and the theory of evolution

The year 2009 has been widely celebrated both as the 200th anniversary of Charles Darwin's birth, and as the 150th anniversary of the publication of "*On the Origin of Species*" which can be taken to mark the beginning of what we now call the 'theory of evolution'. The anniversary has been widely celebrated around the world by media coverage, conferences, educational work and by the publication of a whole raft of new

books. It would be impossible to review them all here. The Darwin 200 website has a list.

Here, I review three books that I have found interesting and illuminating in different ways.

Why Evolution is True
Jerry A Coyne

Oxford University Press, Oxford, 2009. 309 pages + xx, hardback. ISBN 978-0-19-923084-6, £14.99.

Jerry Coyne is a well-known American evolutionary biologist. A student of both the population geneticist Richard Lewontin and the evolutionary biologist Ernst Mayr his field is how new species are formed, using fruitflies as his study group. He has been active in the public debate in the USA on evolution versus creationism, and this book is written to demonstrate how the various forms of creationism fail to explain the findings of evolutionary science, and to provide a short overview of those findings.

The book starts with a preface and introduction on its purpose: specifically, the persistence of creationist views in some countries, and less so in others: in the most recent poll, 39% of Americans claimed it is false that humans "developed from earlier species of animals", 21% were unsure, leaving only 40% who regarded this as true. There follow nine chapters on different aspects of the theory of evolution; then notes, a glossary, suggestions for further reading, references (organised by chapter), illustration credits and index. The writing is vigorous, making for an easy read, and the structure is designed to make it easy to understand, but also to follow up details in the notes and references (though the lack of in-text references can make following up particular points to their source a little troublesome).

The main chapters cover the various aspects of the basic theory, the fossil record, the evidence from embryos and anatomical vestiges, biogeography, natural and sexual selection, and speciation. The final two chapters go into human origins, then a discussion on why evolution remains controversial for some people. The writing is non-technical, aimed at members of the general public with an interest in science, but contains enough in the way of interesting examples to be worth reading even for those familiar with the basic story. He updates Darwin – noting, especially that '*On the Origin of Species*' was not well named, since it had little to say on how new species formation occurred – but repeatedly comes back to how prescient Darwin was even on aspects where the evidence in the mid 19th century was poor, such as the African origin of the human species.

I particularly enjoyed Coyne's coverage of the fossil record, where he points out the several cases where palaeontologists have successfully predicted that fossils of key intermediates should occur in strata of a particular age in a particular location; also his examples of vestigial organs and the deductions to be made from both the presence and absence of particular classes of organism on isolated islands. On speciation, a student of Ernst Mayr is likely to be a strong advocate of the Biological Species Concept and allopatric speciation: he does go into sympatric speciation, and speciation by hybridisation a little, but not into the genetic leakiness of interspecies boundaries, nor into the practical problems for the taxonomist of determining where boundaries are.

His account of human origins is very clear, cutting through the sometimes heated arguments of the paleoanthropologists; he is pretty dismissive (correctly, in my view) of the attempts by evolutionary psychologists to ascribe an evolutionary origin for every aspect of human behaviour, mainstream and aberrant.

Will this book change the minds of any creationists? In his final chapter, he accepts that the scientific evidence is not the issue. In the USA at least, the evolution-creation debate is part of the cultural wars between conservatives and liberals about human purpose and morality. These have nothing to do with the science of evolutionary biology, but creationists aren't really listening.

I felt he missed one argument, and that is on the practical importance of a good understanding of evolutionary processes, especially in the field of medicine: Nesse and Williams's book '*Darwinian Medicine*' is a conspicuous absentee from the reference list.

I found very few errors: Figures 24 and 25 give different generic names for the same human species, *Homo* and *Australopithecus habilis* – this is a real subject of contention, but it needed explanation. Occasionally, the American English may grate on British ears, apparently unedited for the UK printing. All in all, an excellent and worthwhile read.

Darwin's Sacred Cause: race, slavery and the quest for human origins
Adrian Desmond and James Moore

Allen Lane, 2009. 485 pages + xxi, hardback. ISBN 978-1-846-14035-8, £25.00.

Desmond is a London-based writer and researcher on Victorian science, especially the theory of evolution on which he has written several previous books. Moore is a science historian at the Open University, who has also written previously on evolution. The pair previously collaborated on a prize-winning Darwin biography in 1991.

This is a painstaking work of research and scholarship with an introduction and thirteen chapters, followed by

45 pages of notes, mainly indicating the sources of particular points, then 35 pages of bibliography, and finally a comprehensive index. There are 30 contemporary figures and photographs. This may sound unappealing for holiday (or any other time) reading, but once I got into their style, I found the book enthralling and increasingly hard to put down.

Essentially, the book is about a previously little-noticed aspect of Darwin's life and the background history to the publication both of '*On the Origin of Species*' and 'The Descent of Man, and Selection in Relation to Sex' (and why these latter topics were published together).

Darwin's family (including his association with the Wedgwoods who were related to the Darwins, and who eventually supplied his wife Emma) was heavily involved in the battle to abolish slavery: first the slave trade in the British dominions in 1807 (before Darwin was born) and eventually slavery itself in all British colonies in 1833 (when Darwin was on the voyage of the *Beagle*, and where he had plenty of opportunities to see slavery still in action). This was not the end of slavery elsewhere, of course, and the Darwin/Wedgwood family remained active in anti-slavery campaigning during the upheaval that culminated in the American Civil War, beginning mid 1861, less than two years after the publication of '*On the Origin of Species*'.

The original Christian position was that all human beings were descended from Adam and Eve and therefore clearly a single species. For this reason, among others, the anti-slavery movement had strong religious and moral underpinnings. The science of human unity was advocated most strongly by Prichard in his '*Researches into the physical history of man*' which ran into four editions and eventually five volumes between 1813 and 1847. Prichard's work was a key source for Darwin. However, around the time when Darwin spent his year as a medical student in Edinburgh, the 'science' of phrenology was becoming popular: this claimed to be able to identify the characters of individuals and races by describing brain capacity and the relative sizes of bumps at the skull/brain border. The phrenologists, such as the Edinburgh anatomist Robert Knox and the Americans Morton, Nott and Gliddon in books such as '*Crania Americana*' (1839) and '*Types of Mankind*' (1854) came to dominate the young science of anthropology and claimed that humanity comprised a set of separate species with an easily discernible hierarchy, white Anglo-Saxons on top and black Africans at the bottom. The title of one of Nott's papers (1843) gives the flavour 'The mulatto a hybrid – probable extermination of the two races if the whites and blacks are allowed to intermarry'.

Darwin regarded phrenology and its deductions of humans as comprising separate species as nonsense. He also had personal experience (from his Edinburgh and 'Beagle' days) of black people of high intelligence and ability. But for the slave-owners, the claims of the phrenologists provided a justification. Sadly, many well-known 19th century figures accepted the argument, notably Thomas Carlyle, Charles Kingsley and the Swiss zoologist Louis Agassiz; even Charles Lyell, Darwin's friend and mentor, who had many slave-owning friends in the US Southern States, was inclined to accept the argument, to Darwin's dismay. (Darwin had other 'issues' with Agassiz: one of Darwin's few real blunders came in his first full scientific paper where he argued that the Scottish Glen Roy 'roads' marked the positions of ancient sea beaches; Agassiz correctly identified the 'roads' as the shores of glacial lakes.)

Desmond and Moore contend that the origins and diversification of humans were Darwin's central concern, and that his intention was to include humans in his planned huge book on natural selection. He was well aware that his conclusion on the unity of the human species would delight the anti-slavery movement, but that his wider theory that all species were related through common descent, especially humans with other primates, would dismay many of the same people. As is well known, Darwin was 'bounced' into premature publication of what he regarded as an abstract of a larger work by the arrival of Wallace's paper proposing a mechanism for adaptive change essentially the same as Darwin's natural selection. Even so, the origin of humans was intended to be part of '*On the Origin of Species*', but Darwin realised that for this aspect not to wreck the reception of the theory as a whole, he needed the evidence to be watertight. This, combined with his persistent ill health, led him to complete '*On the Origin of Species*' with merely a tantalising sentence on humans "Light will be thrown on the origin of man and his history".

Darwin had concluded, not entirely correctly as it has turned out, that the differences between the human races could not be explained as adaptations to geographical/climatic conditions. Instead, he took sexual selection, which he had identified as a widespread force in nature, generating features that could be seen as disadvantageous to the survival of individuals, as the prime driver of human racial diversification. This was why, when he eventually got round (1871) to completing his work on human origins that he linked the topic with sexual selection.

Anyone interested in Darwin, the history of science, and the interaction of science with its social and political context, will find this book fascinating. Highly recommended.

Darwin's Island: the Galapagos in the garden of England

Steve Jones

Little, Brown, 2009. 307 pages, hardback. ISBN 978-1-4087-000-6. £20

Steve Jones is well-known as a professor of genetics (University College London) but in recent years more as one of the public faces of science, through media appearances, a newspaper column, a Reith Lectures series, and a growing list of books. '*Darwin's Island*' is his contribution to Darwin 200. The concept behind the book is excellent: to remind readers of Darwin's work other than '*On the Origin of Species*'. So, between introductory and closing chapters are nine extended essays:

The Queen's Orang-Utan – on human evolution.
The Green Tyrannosaurs – on insectivorous plants and other interactions between plants and other organisms.
Shock and Awe – on human emotions and their origins.
The Triumph of the Well-Bred – on cross breeding and self-fertilisation in plants; and flower diversity.
The Domestic Ape – on plant and animal domestication.
The Thinking Plant – on movements in plants.
A Perfect Fowl – on barnacles (if this sounds bizarre, it derives from a 17^{th} century claim that geese grew from barnacles: hence both goose-barnacles and barnacle-geese).
Where the bee sniffs – on orchids and their pollination.
The worms crawl in – on Darwin's last book, about worms and their role in soil.

Each chapter presents an account of Darwin's work – some of it in his own garden and the surrounding Kent countryside, hence the book's title – with reflections on where we have got to now, especially in the field of genetics, Jones's expertise and essentially unknown to Darwin and his contemporaries. The final chapter is a reflection on the changes in the world since Darwin's time; mainly on how the diversity generated by evolutionary processes has been rapidly reduced by the results of human activity: over-exploitation, alien species, farming practice, urban sprawl – an all too familiar list. He also discusses whether natural selection is still a force in the human species, concluding that it is much reduced and may cease – though he notes that evolutionary biology can rarely be a predictive science.

There is much fascinating detail in this book, and I'm sure that even the best informed natural historians will learn something new. However, I felt dissatisfied for several reasons. Although there is an index, there are absolutely no references or guides to further reading, so that anyone wishing to follow up particular aspects is completely in the dark: I find this hard to excuse. There are also no illustrations, other than a small sketch or photograph beneath each chapter title, all unlabelled and uncredited: many of the topics would have been considerably enhanced by illustrations, and at £20, this is not an especially cheap book.

Another problem is in the writing. Jones has gone for a vigorous style, full of metaphor, presumably aiming for an audience beyond the normal for semi-popular science. Here is an example "Even bacteria behave in a rational fashion when they settle down close to a source of food, or join hands with their colleagues to form a sticky film over teeth or wounds" (p.78). You see what I mean: in what sense do bacteria "behave in a rational manner" or "join hands with their colleagues"? This kind of writing becomes a particular problem when a precise scientific distinction is needed: on p.42, Jones tells us that chimpanzees (and other animals) do not 'teach' their offspring; but, later (p.49) meerkats 'instruct their infants'. Is Jones using 'instruct' figuratively, or does he intend to tell us that meerkats have evolved a behaviour that chimpanzees have not? On p.4 we are told that "Charles Darwin was the first popular science writer": I've seen many earlier writers claimed for this accolade, from Robert Hooke's seventeenth century '*Micrographia*' onwards, but perhaps Jones has a definition of 'popular science' that fits no-one before Darwin. Perhaps I am wrong, but this book feels like a publisher rushing out a production to meet the anticipated anniversary demand. A little more care could have produced a better book, and the subject is well worth the attention.

From Peat Bog to Conifer Forest: an oral history of Whitelee, its community and landscape

Ruth Tittensor

Packard Publishing Ltd, Chichester, 2009. 237 pages, softback, illustrations in colour and black & white, maps diagrams and tables. ISBN 978 185341 142 7, £27.50.

This book contains the results of an oral history project that commenced in 2004. It provides useful insights into the lives of the people who lived and worked during the 20^{th} century on the Whitelee plateau, which occupies parts of Ayrshire, Lanarkshire and Renfrewshire, and on which is built Scotland's largest wind farm. The changes in land use from sheep and some dairy farming since the 1950's are documented as well as the difficulties encountered during the process of afforestation. Methods of tree planting are discussed as are the types of machinery used in the process; a process that was both difficult and sometimes dangerous. Interviewees' comments on the changes in the flora and fauna as a result of tree growth and coninued planting, of Sitka spruce mainly, are fascinating as are the glimpses into changes in political thinking and its effect on forest management. The book would have benefited from the provision of more detailed maps but is a fascinating read and will be of value to the historian, sociologist, naturalist and general reader. It is well worth the money.

Margaret M H Lyth

The History of Natural History, an Annotated Bibliography (second edition)

Gavin Bridson

Linnean Society of London, London. 2008. 1032 pages, hardback, illustrated with colour plates, drawings and photographs. ISBN-978-0-9506207-8-7, £65.00.

To anybody with an interest in the bibliography of natural history the name Gavin Bridson will be familiar. He worked first as Librarian at the Natural History Museum (London), The Linnean Society of London, and latterly as Bibliographer at the Hunt institute for Botanical Documentation in Philadelphia. His previous works, *Natural History Manuscript Resources in the British Isles* (1980), compiled jointly with Valerie Phillips and Anthony Harvey, and *The History of Natural History: an annotated bibliography* (1994), have long been staple references for scholars interested in the history of natural history. Indeed many authors, having produced such already voluminous compilations, might have been quite content to feel that they had done enough and rested on those considerable laurels. Not Gavin Bridson, who devoted many years of hard labour to this updated version. Sadly he did not live to see it through to final fruition.

This new edition of his earlier work has now been considerably updated (with over 5,300 added references to the first edition) and encompasses the entire subject area. A weighty tome (of 1032 pages, weighing in at nearly 2.8 kg!), it is no light bedtime reading. It is, however, an essential guide to sources of information on histories, bibliographies, biographies, library resources etc. for all naturalists of an historical bent. The Linnean Society is to be congratulated on having the foresight and resources to devote to publishing this work. It looks delicious and is a high-quality production in every sense of the word. It has done him proud. The main sections cover: personnel, organisations, current awareness, Club, Society, Association and Academy history, library history and resources, history of natural history, history of botany, history of zoology and history and bibliographic methods. If you need, say, to find out what library resources relating to natural history exist in the Rossiiskaya Akademiya Nauk .. Botanicheskii Institut im V. L. Komarova, St Petersburg or where to go for what sounds like a revealing study on *American naturists* (N383 Tracy, H. C., 1931) then look no further than this vade mecum. The trouble, of course, with all such compilations – no matter how voluminous - is that they are immediately out-of-date. New material keeps getting produced which is most frustrating to compilers. What can be said, however, without a shadow of a doubt is that this compilation becomes immediately the fount of present-day wisdom on the subject. Sadly, the price reflects its size and complexity. At ?65, only the real devotees of the topic will feel inclined to purchase it, but to them it will be an essential book to have on their (strengthened?) shelf. It is to be hoped that libraries will not flinch from finding the resources to purchase such a key work of reference.

Geoff Moore

Natural history societies and civic culture in Victorian Scotland

Diarmid A Finnegan

Science and culture in the nineteenth century, Series editor, B. Lightman. Pickering & Chatto, London 2009. 254 pages, hardback, black & white photographs. ISBN-13: 978-1851966585, £60.

This is an academic treatise in book form, discoursing its subject as the ninth in a series of volumes on science and culture in the nineteenth century. It ranges widely over its subject, grouped in seven chapters. Starting with Founding Narratives there are five more headings – Fieldwork and Excursion Culture, Natural History and Civic Pride, Natural History and Self Culture, Organising Subscriber Science and Scientific Motives and Civic Virtue. Finally, there is the 'Conclusion' which precedes the notes and sources numbered within the text; with the index this last section amounts to nearly a third of the entire volume. The text is written in the argot of cultural geography and as with any jargon tends to exclude readers who are not familiar with it or at least makes for difficult reading in parts. However, there are summaries for each chapter and the final section musters the overall thesis. The author suggests at the beginning that there is a uniquely Scottish character to the activities of natural history societies. This idea is linked to connections between this activity (referred to as associational science) and local and national identity.
For example, it says that the pleasure and romance of fieldwork was often stressed by Scottish societies. It is equally possible that other regions of the United Kingdom stressed this aspect of their programmes. No analysis of this is offered. All local natural history societies' activities will be subject to parochial differences or even include an element of national pride and carry a belief that their activities are focused on important issues. There is much to ponder and consider in relation to the subject for which this volume makes an excellent source. Given the level of detail and comprehensive notes it should also act as an impetus to further research. Patrick Geddes, the influential professional biologist and town planner, who extolled the virtues of natural history societies, is credited with the phrase "Think global, act local". This concept resonates particularly for modern natural history societies, contemplating species and habitat conservation, climate change and other issues. These subjects are addressed at local levels by membership organisations yet have an impact beyond their boundaries, be it in Scotland or any other country in the world.

E. Geoffrey Hancock

PROCEEDINGS 2009

The Chair, place, lecturer's name and title of lecture are given for most meetings. GKB - Graham Kerr Building. All meetings were well attended.

13th January
Roger Downie, GKB Lecture - Mark Watson "Plant collecting in the Himalayas"

10th February
Roger Downie, GKB,Lecture -Peter Macpherson "Thirty Years as Plant Recorder for Lanarkshire – the Pearls and Perils" Tutorial by Dominic McCafferty on writing for the Glasgow Naturalist.

14th February 150th Anniversary of the publishing of the *Origin of Species* All day joint meeting with DACE and Glasgow Science Centre.

24th February
Roger Downie, GKB, 79th AGM followed by talk "Conservation and Community in Ecuador: six years of the Payamino Project" by Stewart White

10th March
Roger Downie, GKB, Members Photographic Night Preceded by tutorial by Mike Rutherford on Spiders

14h April
Roger Downie , GKB, Lecture by Mike Hansell "Birds Nests in Museum Collections – Why?"

12th May
Roger Downie , GKB, Lecture by Helen Cole –"Ben Lawers, Peak of Plant Conservation" Tutorial was by Jeanne Robinson on Dragonflies

Excursions 25 excursions took place throughout the year. Including Summer Social to Strathblane Country House Hotel with Falconry display beforehand..

15th September
GKB, Exhibition meeting with wine and cheese.

7th October
Roger Downie, GKB, BLB Lecture. Prof. Peter Slater. "Learning about sound in Animals".

13th October
Roger Downie, GKB, Jim Coyle MBE "Biodiversity in Glasgow" Tutorial on Harvestmen by Mike Rutherford.

10th November
Roger Downie, GKB, "Evolution and diversity of Trees" Richard Ennos. Geoff Hancock. gave a tutorial on Bees.

8th December
Christmas Dinner held in Café Direct. Speakers S Rogers, K Baker, S Clennell & L Seaton

Officers and Council
Elected at the 2009 AGM

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John Knowler PhD

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Anne Orchardson (Minute Book)
Avril Walkinshaw (Social)
Anne Orchardson (Excursions)
Roger Downie (Winter Programme)

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John Knowler BSc, PhD
Technical Advisor – Richard Weddle

The Glasgow Naturalist

Advice to Contributors

1. The Glasgow Naturalist publishes articles, short notes and book reviews. All articles are peer reviewed by a minimum of two reviewers. The subject matter of articles and short notes should concern the natural history of Scotland in all its aspects, including historical treatments of natural historians. Details of the journal can be found at www.gnhs.org.uk/publications.html

2. Full papers should not normally exceed 20 printed pages. They should be headed by the title and author, postal and email address. Any references cited should be listed in alphabetical order under the heading References. All papers must contain a short abstract summarising the work. The text should normally be divided into sections with sub-headings such as Introduction, Methods, Results, Discussion and Acknowledgements.

3. Short notes should not normally exceed one page of A4 single-spaced. They should be headed by the title and author's name, postal and email address. Any references cited should be listed in alphabetical order under the heading References. There should be no other sub-headings. Any acknowledgements should be given as a sentence before the references. Short notes may cover, for example, new locations for a species, rediscoveries of old records, ringed birds recovered, occurrences known to be rare or unusual, interesting localities not usually visited by naturalists, and preliminary observations designed to stimulate more general interest.

4. References should be given in full according to the following style:

Pennie, I.D. (1951). Distribution of Capercaillie in Scotland. *Scottish Naturalist* 63, 4-17.

Wheeler, A. (1975). *Fishes of the World.* Ferndale Editions, London.

Grist, N.R. & Bell, E.J (1996). Enteroviruses. Pp. 381-90 In: Weatherall, D.J. (editor). *Oxford Textbook of Medicine*. Oxford University Press, Oxford.

5. An organism's genus and species should be given in italics when first mentioned. Thereafter the common name is only required. Please use lower case initial letters for all common names e.g. wood avens, blackbird; unless the common name includes a normally capitalised proper name e.g. Kemp's ridley turtle. The nomenclature of vascular plants should follow Stace, C.A. (1997). *The new Flora of the British Isles*, (Second Edition). Cambridge University Press, Cambridge. Normal rules of zoological nomenclature apply. When stating distribution, it may be appropriate to give information by vice-county.

6. All papers, including electronic versions, must be prepared on A4, double spaced throughout, with margins of 25mm, with 12 point Times New Roman font. Tables and the legends to figures should be typed separately and attached to the end of the manuscript. The Editor can make arrangements to have hand-written manuscripts typed if necessary.

7. Tables are numbered in arabic numerals e.g. Table 1. These should be double-spaced on separate sheets with a title and short explanatory paragraph underneath.

8. Line drawings and photographs are numbered in sequence in arabic numerals e.g. Fig. 1. If an illustration has more than one part, each should be identified as 9 (a), (b) etc. They should be supplied as a high resolution digital image or camera-ready for uniform reduction of one-half on A4 size paper. Line drawings should be drawn and fully labelled in Indian ink, dry-print lettering or laser printed. A metric scale must be inserted in photo-micrographs etc. Legends for illustrations should be typed on a separate sheet. Photographs are normally printed in black and white, however the Editor is able to accept a small number of high quality colour photographs for each issue.

9. Articles should be submitted preferably by email either as a single word processed document or pdf to the Editor: Dr Dominic McCafferty dominic.mccafferty@glasgow.ac.uk or by post (2 copies) to School of Education, University of Glasgow, St Andrew's Building, 11 Eldon Street, Glasgow G3 6NH, Scotland. Photographs and illustrations should be high resolution with a minimum of 300 dpi in tif or jpeg format. Please contact the Editor if you require assistance with photographs as in some cases suitable photographs can be obtained.

10. When the article is accepted for publication, the author should return the corrected manuscript to the Editor as soon as possible. Final proofs should be returned to the Editor by return of post. Alterations at this stage should be kept to the correction of typesetting errors. More extensive alterations may be charged to the author. Once accepted the article may be made available online prior to the final printed version.

11. A copy of the published article will be sent to the first author as a pdf file. Ten reprints will be supplied free of charge for full papers only. Additonal reprints required will be charged at extra cost.

12. All submissions are liable to assessment by the Editor for ethical considerations, and publication may be refused on the recommendation of the Editorial Committee.


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